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DEVELOPMENT AND EVALUATION OF AUTO-INSTRUCTIONAL PROGRAMS IN ARITHMETIC FOR THE EDUCABLE MENTALLY HANDICAPPED. FINAL REPORT.

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THE PURPOSE OF THIS PROJECT WAS (1) TO DEVELOP EDUCATIONAL MEDIA FOR TEACHING EDUCABLE MENTALLY HANDICAPPED (EMH) CHILDREN ARITHMETIC CONCEPTS AND (2) TO EVALUATE THE DEVELOPED PROGRAMED INSTRUCTIONAL MATERIALS. DURING THE FIRST PHASE OF THE STUDY THE ACTIVITIES WERE DEVOTED TOWARD ACCOMPLISHING THE FIRST PURPOSE, DEVELOPING THE EQUIPMENT AND MATERIALS. SEVERAL DEVICES AND COMBINATIONS OF DEVICES WERE USED DURING THE TRIAL PERIOD. THE DEVICE FINALLY DEVELOPED, REFERRED TO AS THE AUDIO-VISUAL MANIPULATIVE (AVM) DESK, PRESENTS INFORMATION ON A SCREEN THROUGH THE USE OF A SLIDE PROJECTOR. AUDIO MESSAGES ARE TRANSMITTED THROUGH EARPHONES AND A SPEAKER, AND THE CHILD MANIPULATES OBJECTS OR WRITES ON THE RESPONSE SURFACE. TWENTY-ONE DIFFERENT SEQUENTIAL ARITHMETIC PROGRAMS WERE DEVELOPED FOR THE DESK FOR TEACHING EMH CHILDREN SKILL SEQUENCES IN ARITHMETIC. DESK ADMINISTERED TESTS WERE ALSO DEVELOPED TO ASSESS THE CHILD'S UNDERSTANDING OF THESE CONCEPTS. OTHER MATERIALS DEVELOPED INCLUDE--(1) A MANUAL OF INSTRUCTIONS FOR TEACHERS (WHICH INCLUDES THE PROGRAM OBJECTIVES) AND (2) REINFORCEMENT MATERIALS FOR CLASSROOM USE. DURING THE EVALUATION PHASE OF THE STUDY, FOUR SEPARATE FIELD STUDIES WERE CONDUCTED. THE RESULTS OF THESE STUDIES SHOW--(1) THE AVM SYSTEM WAS AN EFFECTIVE VARIABLE IN PRODUCING DIFFERENTIAL RESULTS, (2) GOING THROUGH PROGRAMS TWICE DID PRODUCE HIGHER POST-TEST SCORES THAN GOING THROUGH THE PROGRAMS ONCE, (3) THE SYSTEM COULD BE USED EFFECTIVELY IN A CLASSROOM SETTING UNDER THE SUPERVISION OF CLASSROOM TEACHERS, AND (4) PROGRAMS DEVELOPED FOR EMH CHILDREN WERE NOT APPROPRIATE FOR TRAINABLE MENTALLY HANDICAPPED CHILDREN. THE APPENDIXES INCLUDE DETAILED INFORMATION ON THE DESK AND ARITHMETIC PROGRAMS. TWENTY-THREE REFERENCES ARE LISTED. (AUTHOR)

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FINAL REPORT
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August 1967

U.S. DEPARTMENT OF
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Project No. 2514
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Conwell Higgins
Reuben R. Rusch

August 1967

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Albany Public School

Albany, New York

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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I. Introduction

The statement of the problem, the background, a review of related research and the purposes and objectives of the study are considered in the introduction.

A. Problem

When children enter the first grade, certain assumptions are made concerning the concepts that they have developed previous to entering school. And, as they continue through school, each teacher continues to make certain assumptions regarding the concepts that children have learned in the preceding year. These assumptions are often incorrect for all children and in particular are incorrect for handicapped children. Because of their special handicaps they may proceed at a different rate of **growth** than the average child; they may not possess certain concepts; they may learn new concepts more slowly, and assumptions regarding the concepts they possess, as they continue in school, become more and more precarious.

Even in special classes for the educable mentally handicapped children, there is a wide range in the concepts grasped. Thus, in spite of the fact that class size is reduced, because of the nature of EMH children, a considerable amount of the teaching time is devoted to teaching a given concept to a very few, or to only one child at a time.

It has been estimated by Mayo (14) that there are currently 1,250,000 mentally retarded school age children and that only about 250,000 of these children are enrolled in special classes wherein because of reduced size, special teacher competence, and the homogeniety of the group, some attention may be given to individual concept development. However, the other four-fifths of the mentally retarded school age population, not in special classes, may not be expected to receive the individual attention necessary to develop these concepts.

One area in which help may be found for teachers in their attempts to deal with individual differences is programmed instruction. To have programmed materials available which are able to identify whether children know certain concepts and to have programmed materials available to teach handicapped children the concepts they lack, should be an asset to the majority of these children, regardless of whether they are located in special classes or in regular classrooms.

B. Background

The Albany Public Schools have a long history of interest in exceptional children and youth. In 1911 and 1912, staff were sent to Vineland to be trained to work with handicapped children. In 1912 the first special classes for handicapped children were established. Special classes have existed in the Albany Public Schools since that time and many specialized services have been added for many kinds of handicapped children.

In 1947 further interest was shown in research and the needs of special children with the appointment of a Director of Research and Psychological Services. More recently there has been an even greater attention to experimentation and research. In 1958 through 1961 the Albany Board of Education and the New York State Education Department jointly sponsored an experimental program concerned with "Identification and Education of the Academically Talented." In 1961-1962 these same two agencies jointly sponsored a longitudinal study entitled "Patterns of Basic Skill Growth: Ages 9-11."

In 1962 the Albany Board of Education appointed a staff member to work in the area of programming. In addition, supporting space, facilities, and materials were provided.

The initial activities of the programmer were devoted to the teaching of fractions. In an effort to stimulate conceptual development and transmit knowledge, programs were developed which provided for both control of and monitoring of pupils' behavior. The pupils were led to make overt responses, both oral and manipulative, through oral and visual cues, in carefully directed sequences. Each teaching frame in the sequences was visually and/or orally reinforced. The locally sponsored activities utilized the Graflex Audiographic and LaBelle Teleguide machines, in which the visual material was presented in the vertical plane and manipulative responses were made on horizontally placed magnetic boards. No provision was made for written responses.

These techniques are best illustrated in the program written to teach the concept of one-half. Near the beginning of the program the pupil is directed by the voice on the tape to pick up the two red parts or pieces on the table and place them together on the magnet board in front of him. Sufficient time is allowed for him to execute the direction. A colored slide of the two parts correctly fitted together is then projected on the screen, the visual reinforcement. The voice then asks how many parts or pieces he fitted together. The cue to the correct response of two had been given twice by the voice in the previous direction. Again time is allowed for the pupil to respond orally. The taped voice then says "two parts," reinforcing his response.

In very small steps, in the form of manipulative action and questioning, the pupil is brought to the concept that two equal parts of one when separated are one half of the whole, and when fitted together, make one whole. He is then directed to put the objects he used back on the table. He is then shown pictures of birthday cakes, pizzas, and other subjects, both round and oblong in shape. These are presented in wholes or halves and the pupil is asked to identify parts and the whole.

All of the early programs were machine paced which sometimes lead to inattention of the older children and frustration of the younger children.

Because many of the concepts contingent on an understanding of fractional relationships were not understood by the EMH children, the programs on fractions were not field evaluated. The decision was to resume programming of fractions after requisite concepts for understanding of fractions had been written and field tested.

C. Related Research

At present teaching of arithmetic concepts to the mentally handicapped is generally restricted to manipulation of objects, paper and pencil activities suggested in texts and workbooks. These activities are used in both group and individual instruction. An increasing understanding of the relationship between sensory-motor exploration and the development of sequential concepts has occurred, e.g., Piaget (19), Stern (22), and Bruner (7). Much effort has been invested in the preparation of sequential arithmetic curricular guides for the EMH, e.g., Lynch (12), Goldstein and Seigel (9), Sisters of St. Francis of Assisi (21), and Connor and Talbot (8).

Stern (22), as an outcome of her work with nursery school children, concluded that guided sensory-motor experience, using structured three-dimensional objects, was crucial in the discovery and/or understanding of arithmetic concepts. The tactics of Stern are loosely structured and learning results from spontaneous "insight or discovery." Ives (10) explored the effectiveness of the Stern method with a small sample of children (7-11 years old) who comprised a special class of "backward" children. Ives concluded that use of apparatus which structures the properties of the number system was more effective than use of sticks used as computational aids, even though in both groups the major emphasis was upon an understanding of processes rather than on rote operations.

Bijou et al (2) carried out a three-year study in which retarded children were taught reading, writing and arithmetic through the use of operant conditioning techniques and programmed instruction. The report considered the rationale of strategies and tactics in developing academic and social behavior, briefly described programmed materials and summarized principles in the education of the mentally retarded. The focus of the report was on process rather than on evaluation of the programmed materials.

Results have been reported on the relative effectiveness of programmed materials and conventional teaching methods. Price (20) compared two automated methods, i.e., answer-construct, and multiple-choice, with a conventional teaching method. The twelve factor table in addition and subtraction was used as subject matter. Significant improvement resulted in the learning of subtraction by the multiple-choice machine group. No significant difference was found between the groups in respect to addition. However, the two machine-taught groups required considerably less time when compared with the conventional teaching group.

McIntyre (16) hypothesized that pupils at the lower IQ level of the educable range would acquire a greater number of addition facts via massed repetition in programming, while pupils at the higher IQ level of this range would demonstrate more learning when exposed to distributed repetition of items. The hypothesis was rejected because alternative types of programming for these different IQ levels were found to be unnecessary. Higher and lower IQ levels did not differ significantly on the massed repetition program. Significant increases were reported in both acquisition and application for all groups combined. The author further noted a practical aspect of programming in that the children attended for a longer period of time when engaged in the programmed instruction.

In assessing the differences in the rate of learning arithmetic computational skills, Merachnik (17) using two groups, one teaching machine, the other, small group teacher instruction, found a significant difference in Pre and Post Test gains, favoring the experimental group.

Blackman (3) compared the achievement of two equated groups in primary reading and arithmetic. One group was taught via machine presented programmed instruction plus regular instruction, while the second group was taught by traditional methods. The dependable variable was measured by: First, Wide Range Achievement Test; Second, Metropolitan Achievement Test; and Third, C & G (a test specially constructed to measure programmed materials). Significant improvement was shown by both groups in reading and arithmetic as measured by the three criterion tests. However, there were no significant differences between the improvement scores of the machine and nonmachine groups on two of the achievement scales. On the C & G Test arithmetic gain scores were significantly larger for the machine group than for the nonmachine group. The comparison of the two groups on the Behavior Basal Scale demonstrated statistically significant improvement favoring the machine group.

In a somewhat similar study, Blackman and Capobianco (4) found no significant difference in the teaching of reading and arithmetic to educable retarded young adolescents by programmed instruction compared to the traditional special class techniques. The authors suggest that due to the large quantities of material required and the limited preparation in program writing, the programs used in the study may have been of inferior quality and hence a mitigating factor in the study.

In evaluating the performance of mentally retarded children on a teaching-machine program written for normal children Bradley and Hundziak (5) administered the TMI Grolier Time Telling Program. The findings suggested that not only can mentally retardates learn from a program written for normal children but that such a technique has a prime advantage in rapidly determining learning problems.

Malpass et al (13) evaluated the utility of the automated teaching devices, a semi-automatic multiple choice teaching machine and a fully automated teaching machine. They compared these two with the conventional methods of teaching word-recognition and spelling skills. The automated procedures proved to be effective for learning and more efficient than conventional methods. Both automated methods engendered higher levels of retention in word-recognition and spelling. The semi-automated and keyboard methods were not significantly different from each other in most instances.

Kunkel (11) found that the use of programmed material in the teaching of spelling resulted in significantly less time consumption than when taught by conventional methods.

An interim report of a long term study in which sophisticated computer techniques are used in teaching modern arithmetic to bright primary children (Suppes, 23) indicated that even with this sample, daily drill in the basic skills is desirable even though the main curriculum work consists of extensive supplementary material. This finding suggests that no single arithmetic sequence programmed for EMH children is an easy answer to learning problems.

Overall, programmed instruction for EMH children has been shown to be effective. In teaching the educable mentally handicapped this instruction has also been demonstrated to be more efficient in that the time required to learn is reduced.

D. Purpose

The overall purpose of this study was to develop audio-visual equipment and materials for teaching educable mentally handicapped children arithmetic concepts and to evaluate the developed programmed instructional materials.

During the first phase of the study (February 1 1965) through August 31, 1966) the activities were devoted to accomplishing the purpose, tho developing of audio-visual equipment and materials. Specifically this purpose was: First, to develop economical audio-visual equipment, and Second, to develop audio-visual programs applicable for use with economical equipment for teaching selected arithmetic concepts to EMH children. The development of audio-visual programs included in-shop evaluation and program modification. The arithmetic concepts for programming were selected from those developed by Lynch (12), Goldstein and Seigel (9), and Sisters of St. Francis of Assisi (21). A third specific purpose was to develop programs to assess whether each of these concepts and fundamentals were known by the children. Associated with this third purpose was the development of an outside Criterion Test.

It was realized, as the programming progressed, that if these programmed materials were to be efficiently used in classrooms by teachers, it would be advantageous to prepare accompanying classroom activities so that the teacher could guide the children in the social application of the programmed concepts. Thus, in September, 1965, the project took on the added purpose of: Fourth, preparing accompanying materials and activities for classroom reinforcement of criterion behavior.

During the second phase of the study (September 1, 1966 through August 31 1967) the activities were devoted to accomplishing the second purpose, evaluating the developed programmed materials in the classrooms. Specifically, this purpose included: First, comparing EMH students taught by conventional classroom methods; Second, comparing EMH students exposed to the programs once with those exposed two times; Third, determining the effects on pupil performance of teacher use of the instructional system; and Fourth, determining the effectiveness of selected programs in teaching the trainable mentally handicapped.

II. Method

Development of equipment, preparation of instructional materials and evaluation are described.

A. Design and Development of Economical Audio-Visual Equipment

The development of economical audio-visual equipment was undertaken before the grant was received and continued during the first phase of this project.

The present audio-visual manipulative desk (AVM Desk) was developed over a period of six years. The first device used in the presentation of arithmetic programs was the Audio-Graphic, manufactured by the Graflex Corporation. This device was an automatic slide and magnetic tape presentation device for industrial training. It was capable of handling 45 slides and 45 minutes of magnetic tape presentation. Although the Audio-Graphic was an extremely sophisticated piece of electronic equipment, numerous technical difficulties prevented full utilization of its capabilities.

The second device used was the Teleguide manufactured by the LaBelle Corporation, designed for industrial training. It had a 45 slide capacity but a smaller audio tape capacity. Technical problems with the slide mechanism and the preparation of audio tapes prevented effective utilization of the device.

The Audio Graphic and the Teleguide were the audio-visual devices used from 1961 to 1965 in developing and testing AVM programs. This equipment presented the visual information on a vertical screen and the children manipulated objects on a magnetic board.

The current AVM Desk consists of a Kodak cartridge slide projector in which the visual materials are projected on a horizontally placed screen, and a loop tape player (Tape-Dek II). The child monitors the tape through earphones and writes or manipulates objects on the screen. Visual and auditory reinforcement is used. The programs are pupil paced for all frames which involve manipulation. A complete description of the equipment, including electrical circuits, is presented in Appendix A.

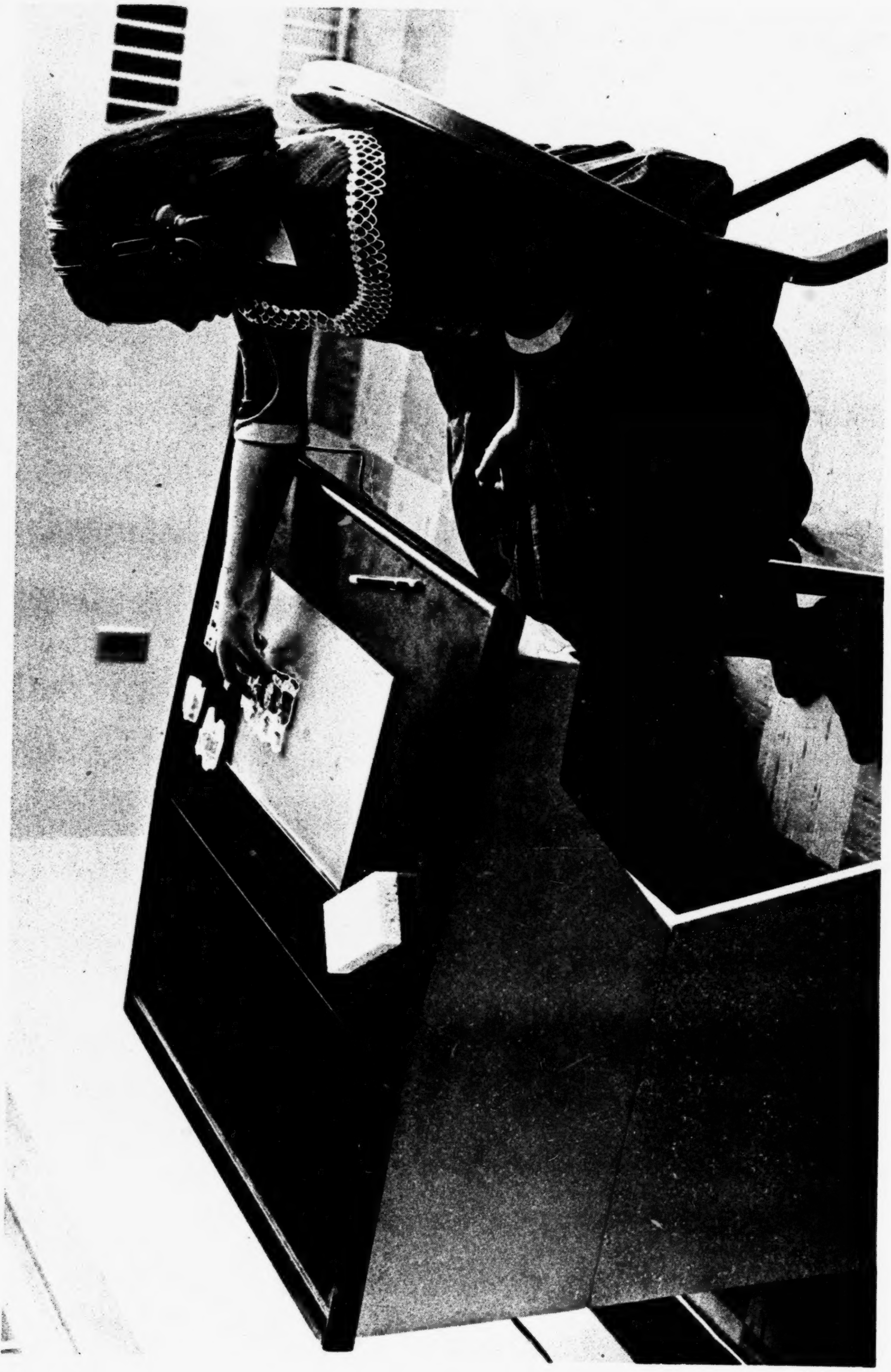


Figure 1. LEARNING ARITHMETIC AT THE AVM DESK

B. Development, Evaluation and Modification of Audio-Visual Programs in Arithmetic

The rationale of the programmed arithmetic concept sequence and the problems of script preparation are discussed.

1. Rationale of Arithmetic Concept Sequence. The sequence of instruction begins with physical representation of the numerical properties of things and builds progressively to symbolic representation, i.e., an arithmetic concept is developed first with objects, then pictures, and finally numerals. Widely differing stimuli are presented to the child without presuming any ability on his part to read. The sequence links together the concrete manipulative behavior in which the EMH child has some facility with the abstract symbolic behavior with which he has difficulty. In a sense, it is a means of connecting, doing, seeing and saying into a highly organized multi-sensory learning experience.

Information necessary to learn an arithmetic concept is coded in terms of objects, pictures, and words, and stored in manipulative materials, visuals and tapes in the programmed sequence of instruction. The programs are communication tools which enable the child to retrieve the information through learning, seeing, and manipulating.

Unit I illustrates the sequence of concepts. Naming a group of objects as a set and ability to form a set of specified objects is the immediate criterion behavior of Program I. This leads to the concept of addition as being an increase in the number of objects in a set, subtraction as being a decrease in the number of objects in a set.

Naming an individual object in a set as an element and recognizing that objects not in a set are not elements is the immediate criterion behavior of Program 2. This leads to the concept of an element's "oneness" as a property and the joining to the set of other elements as changing the numerical property of the set. In subsequent units, the similarity of different sets, as far as numerical property is concerned, is shown by referring to the objects in the sets as elements. The element property is the unifying idea of objects in a set, e.g., one of the most difficult answers for a teacher to obtain is one which requires the child to group together elements which are different in some way. If a child is shown a picture of three boys and two girls, and asked how many children there are, he quite often responds, "three boys and two girls." However, when he is guided to the concept of elements grouped together as a set, he more often will give the correct answer regarding the relationship of the parts to the whole.

Ability to match sets of different types of elements and to identify sets as having the same or different number is the criterion behavior of Program 3. This is the basis for subsequent recognition that two sets of different elements can still have the same number . . . . divorcing the "number" concept of an object from its other properties so that the numerical property of a set may be identified by different numerals.

2. Criterion Behavior. The scripts for the programmed instruction and the classroom activities cover all segments of the criterion behavior. For example, in Unit I, Program 1 Sets, the Criterion Behavior includes: verbal specification of a group of objects as a "set," identification of a set as a collection of objects within a circle by pointing, verbal specification of a collection of objects within a circle as "a set of objects," motor specification of set by drawing a circle around objects and motor specification of set by placing objects within a circle.

The Criterion Behavior is presented, program by program, in the Teachers' Manual, Appendix B.

3. Development of Audio-Visual Arithmetic Programs. The programmed scripts were structured upon the Criterion Behavior. The pupils for whom the programmed instruction was designed and the behaviors to be modified were the parameters of the script which specified the visual, kinesthetic and auditory input.

Writing for mentally retarded children in itself presented problems. The writer of programs in general must constantly be aware of his objectives, the criterion behavior, and how they suit the particular needs of the subjects. In writing for retarded children, the programmer must be particularly aware of their ability, yet not neglect their interest level. Two children of the same mental age may be so vastly different in chronological age that a single program may not hold the same appeal. In this project many of the programs and accompanying game activities have been geared to the interest level of the younger child. This does not preclude that the same sequence of instruction may be adapted to appeal to a child of greater social experience.

Instruction must proceed in small steps. After the initial try-out, the programmer may find gaps in the sequence. Structuring of material into small steps has the advantage of insuring success and interrupts the pattern of failure experienced by the child prior to special class placement. By an analysis of his Pre Test scores, a child may be started in an area below his known ability level and proceed to an area of new learning. By fading cues, the complexity of the learning material is gradually increased and a smooth transition is effected from one frame to another.

The initial sequence of concepts structured by the content specialist must frequently be modified. In this project, the concept "same and different number," followed the concept of matching and not matching sets. In-shop evaluation indicated the sequence was faulty because "number" became a meaningless term. Consequently experience with numbers as property of a set was introduced before asking them to discriminate between sets with the same and different number.

Writing a program with small steps and few errors presents a dilemma. How many mistakes are a few mistakes? It is possible to write a program in which the child makes no errors and learns nothing. The criterion used in writing and editing programs was as follows: if, on the third response to a program, 90% of the children make more than 10% errors, the program must be edited.

Short attention span is one of the behavior characteristics of retarded children. While most of the initial programs required about 15 minutes, certain programs required as much as 30 minutes. It was found that the less mature children were unable to attend efficiently to the longer programs so the longer programs were divided into two parts. The optimal time for this sample of children ranged from 12 to 18 minutes. Attention was enhanced by using built in attention magnets. In some instances the sequence of instruction has been set to the background of a loosely woven story, e.g., shopping in a department store, preparing for a party, etc. In other instances, sound effects, e.g., car racing, circus music, have been recorded on the tape at appropriate intervals. Colorful attractive slides and imaginative manipulative objects also reduce inattention. The total AVM tactic, by totally involving the sight, hearing, speech, and touch channels, functions as an attention magnet.

With respect to retention, not only is continual review of previously taught material inserted in the AVM programs but the programs are intentionally redundant by presenting the same concepts in many ways without being repetitious. It is important to avoid repetition in verbal responses as this may lead to perseveration.

As reading ability cannot be assumed for young retardates, verbal input and pictures must substitute; consequently, language must be precise, simple, unambiguous, familiar and meaningful. Pictures must have a commonality to their social experience. Further, to reduce difficulty in visual perception, illustrations must have clearly defined figure-ground relationships and must be sharp and uncluttered. The representation of the numeral one created a problem. At first the Roman form of the numeral was used, i.e., "I." Subsequently new slides had to be made presenting this merely as a vertical line, i.e., "|." The same is true of auditory perception. Verbal directions and questions must be short and precise sentences. Close attention to the technical aspects of the program enhances the teaching effectiveness.

The preparation of the materials for classroom group activities was based upon the criterion behavior used as a guideline in the arithmetic concept sequence.

The completed programs went through in shop evaluations. The inshop evaluation involved a Pre Test, a Post Test, and exposure to the programs one or more times. The inshop evaluation was carried on by a research assistant, in the Psychology offices in Giffen School.

Table 1, Unit I Evaluation: Number of Correct Responses, shows the kind of inshop evaluative information which was collected. The information in Table 1 represents the results for one class of EMH children, for Unit I. The chronological ages of these children, from Column I of the table, ranged from eight years and four months to eleven years and nine months. Their Stanford-Binet IQs ranged from 52 to 80. On the unit Pre Test, before exposure to the programs, the scores ranged from 0 to 8 correct out of a possible 19. On the same unit test given after one, two, or three exposures to each program, the scores ranged from 9 to 15. The gains, column 5, ranged from 3 to 14.

At the time of this evaluation, Unit I was composed of four programs and a Pre Post Test. On program one, each child could respond 28 times; on program two, 34 times; on program three, 44 times; on program four, 33 times. In this evaluation the pupils were exposed to the programs the number of times necessary to meet an arbitrarily selected criterion. For the first program, this score was 21. Those pupils not getting 21 correct responses the first time were exposed a second time. Those pupils not getting 21 correct responses to program one, the second time, were exposed a third time. Only two pupils went through program one, three times (number 8 and 10). On the third time through, child 8 responded correctly every time; child 10 responded correctly 26 of 28 times.

One of the purposes of this particular evaluation and of other similar evaluations was to determine the effectiveness of the programs. It was assumed that if the scores did not improve as a result of repeated exposure, the programs were not ideally effective with these kinds of children, and further modifications in the programs needed to be made. Program four in Table 1 was a program which was subsequently revised. Four of the six children repeating the program did not do better on the second trial. Thus, further trials were not undertaken until the program was modified.

The inshop evaluation summarized in Table 1, conducted with one unit, using one special class, represents only one of many inshop evaluative studies. Other inshop evaluations were conducted with other units and other classes.

Table 1 Unit I Evaluation: Number of Correct Responses

Pupils	CA	IQ	Pre Post Scores			Programs											
			Pre	Post	Gain	1 Trials			2 Trials			3 Trials			4 Trials		
						1	2	3	1	2	3	1	2	3	1	2	3
1	11-4	71	0	11	11	25			29	34		36	40		29		
2	10-6	69	2	14	12	16	26		16	27	29	39			28		
3	11-4	60	8	12	4	14	27		24	30		38			23	ab.	
4	11-7	60	6	14	8	23			32			43			30		
5	9-8	62	5	10	5	17	28		18	23	27	30	38		23	19	
6	11-4	74	4	12	8	24			27	30		40			28		
7	11-9	80	6	9	3	22			18	33		34	42		28		
8	10-7	54	3	12	9	12	20	28	21	28		21	43		23	27	
9	11-2	63	3	10	7	25			30			42			25	25	
10	11-1	69	1	15	14	8	18	26	24	27	33	35	42		27	30	
11	11-4	63	5	10	5	15	23		28	30		26	32	40	25	25	
12	8-8	52	5	10	5	6	26		22	23	26	31	34	40	20	20	
13	11-8	62	4	12	8	24			29			32	43		29		
14	11-7	71	5	15	10	21			27	26	30	37			30		
Possible score			19	19		28			34			44			33		
Criterion score						21			27			37			28		

Table 2 summarizes the final arrangement of the arithmetic programs which were prepared for the AVM System. Four copies of these programs were produced.

Table 2 Arithmetic Units and Programs

Unit I Sets and Matching	Unit II One, Two, Three	Unit III Zero, Four, Five
1. Sets	1. One	1. Zero
2. Elements	2. Two	2. Four, Part I
3. Matching One to One	3. One Plus One	3. Four, Part II
4. Pre Post	4. One Plus One Equals Two	4. Five
	5. Three	5. More Than--Less Than
	6. Same and Different Numbers	6. Counting and Enumeration
	7. More Than	7. Ordinals 1st-3rd
	8. Less Than	8. Ordinals 1st-5th
	9. More Than--Less Than	9. Pre Post
	10. Counting and Enumeration	
	11. Pre Post	

C. Development of Assessment Devices

Two tests were devised to assess the child's understanding of arithmetic concepts. The Pre Post Test was presented in the AVM Desk; the Criterion Test was administered individually.

1. The Pre Post Test. The Pre Post Test consists of frames which elicit criterion behavior and are presented in the AVM Desk without cues or reinforcement. For example, in an effort to avoid teaching terminology in the Pre Post Test, the word "set" is elicited before it is used in the phrasing

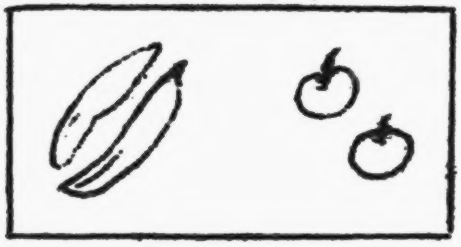
of a question. Also, in eliciting the response, "match one to one," at first the whole phrase is the correct response, then "one to one" and finally "one." This is not a prompting sequence as there are no reinforcements verbalized.

The test frames are similar but not completely identical to the criterion frames of the several programs. This reduces the possibility of memorizing the instructional reinforcements of specific frames. The Pre Post frames were written from the catalogue of criterion behavior rather than selected from the instructional sequences. Of necessity, certain Pre Post frames and instructional frames are identical, e.g., "Read the number sentence, 1 + 3 = 4."

Several frames of the script of the Pre Post Test, Unit I, illustrate the auditory and verbal input.

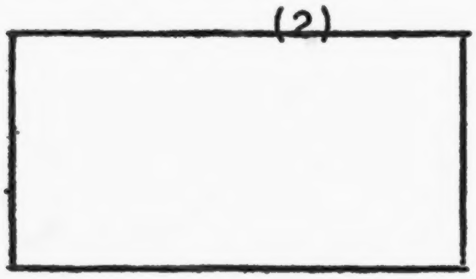
Slide (1)

Frame



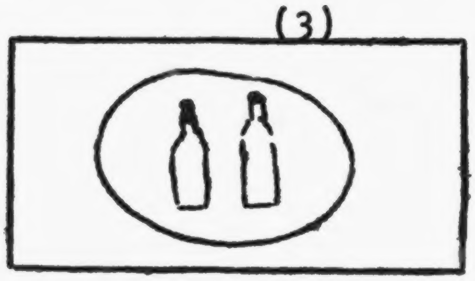
1. Draw a ring around the bananas in this picture. The ring around the bananas in this picture shows that the bananas make a (what?)

(2)



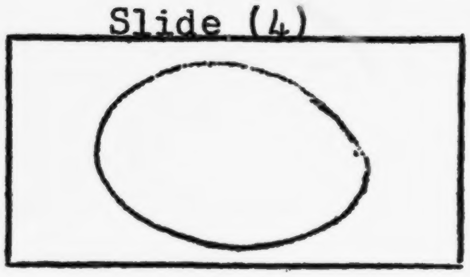
2. Erase the lines on the screen.

(3)



3. There is a ring around the bottles in this picture. This shows that the bottles are in a (what?)

Slide (4)



4. On your desk you have apples, pears, and cherries. Make a set of apples on the screen.

The Pre Post of every unit is a single test. The assessment function is to determine: First, the present status of the child, an inventory function, and Second, the teaching effectiveness of any particular unit. The initial test presentation of several units serves as a guide to place a child in the proper instructional sequence and to avoid the instruction of concepts already known by the child. The score on the test after instruction specifies the amount learned and suggests whether the child should progress to the next unit or should repeat the unit.

2. The Criterion Test. The Criterion Test is an independent measure of the concepts a subject may have gained via the instructional program. Like the AVM Tests, the Criterion Test assesses how well the programmed sequences have met the outlined objectives. However, unlike the AVM Test, this evaluation is removed from the context of the Desk. It is administered individually by an examiner and requires approximately ten minutes.

The test was devised to determine whether or not a subject could transfer concepts learned in the formal instruction and apply them to independent tasks. Where the AVM Test requires responses quite similar to responses elicited in the programs, the Criterion Test calls for more complex tasks. A second purpose of this test is to have an independent measure of the knowledge of these arithmetic concepts.

The Criterion Test is composed of eleven sub tests:

a. Test 1. The subject is presented with a diagram of two sets of two elements. Questioning is designed to elicit three verbal responses which are an integral part of the vocabulary taught in Unit I, e.g., "sets," Program 1, "elements," Program 2, and "Match one to one," Program 3.

b. Test 2. The child is asked to create two sets that match one to one, an extension of the instruction in identification of matching and non-matching sets. The child is presented with a set of two elements, a set of one element, and two similar artifacts. The request is to make the sets match one to one.

c. Test 3. This test is an extension of Test 2. The child is asked to make three sets match one to one. He is presented with a set of five elements, a set of two elements, a set of one element, and two dissimilar artifacts. The child is required to divorce the "number" concept of an object from its other properties.

d. Test 4. This test is somewhat similar to Tests 2 and 3. The child is presented with two sets in which the single elements are dissimilar and one set of two dissimilar objects, and two dissimilar artifacts. He is requested to make the three sets match one to one.

e. Test 5. This test requires the child to write and complete six phrases or number sentences, using numerals or symbols. He then is asked to read the phrase or sentences.

f. Test 6. The subject is presented a diagram of a set of three elements separated into two and one elements. He is asked to identify which of four given equations or number sentences describe the number attribute of the set, e.g., 2 + 1 = 3.

g. Test 7. A diagram is presented consisting of two sets of three elements, and one set of two elements. The child is asked to identify sets which do and do not match one to one.

h. Test 8. The child is asked to compare 3 and 2 by writing the correct symbol. This requires recognition that 3 is more than 2 and ability to write the more than symbol.

i. Test 9. The subject is presented with a series of five dots. He is required to recognize the numerical property of the set and translate it into a written numeral.

j. Test 10. A diagram displays six number combinations. The child is asked to identify the combinations which equal five, e.g., 4 + 1 and 3 + 2.

k. Test 11. The child is presented a diagram of a series of five children and animals. He is required first to count and enumerate those in line, then to name the ordinal position of each.

Each of the subtests was designed to assess a major concept taught in the program development. All of the major operationally defined functions in the instructional sequence are included in the Criterion Test.

This test is presented in the Teachers' Manual, Appendix B.

D. Accompanying Materials for Teachers

Materials were devised for use in teaching the arithmetic concepts of Units I, II, and III, either in conjunction with the programmed instruction or independently.

When used in conjunction with the programmed instruction, the materials and activities serve to consolidate the concepts taught by the AVM Desk programs as well as offer the opportunity for transfer of learning in a social context. In the event the AVM Desk is not available, the materials and activities enable the teacher to elicit criterion behavior and guide the reinforcement patterns of the pupils. The materials and activities result in direct involvement of the teachers in the instructional program rather than being supervisors of a teaching machine.

There is a set of materials for every program of the sequence. Certain materials are designed to be used in a flexible manner so that the imagination of the teacher and pupils came into play while other materials fit into a well defined game format. The suggested activities have a much sharper focus on concepts to be learned than is usually found in classroom play and recreation. The fundamental purpose of the materials and activities is to consummate in the instructional programs John Locke's reverie

> "I have always had a fancy that
> Learning might be made a Play
> And Recreation to children."

The materials and activities for the program Sets illustrate the procedure.

1. Flannel Board

a. Materials. Flannelboard, flannelboard cut-outs: four each of stars, discs, birds, apples, and one large oval-shaped ring.

b. Activity: Scatter the birds, apples, stars, and discs on the flannel board, some inside the ring and some outside the ring. Child and/or teacher requests "Make a set of all the apples." Respondent makes the set and asks, "What is this set?"

2. Game

a. Materials. 8" x 10" acetate cards with attached loop of string, four cards each of horses, cows, pears and apples.

b. A chalk circle is drawn on floor. Children are randomly assigned to two teams. Each team selects a captain. The captains distribute cards which are suspended across shoulders. Captain A selects member of Team B and requests, "Make a set of all the horses." The member of Team B finds all the horses of Team B and leads them into the circle. Children in the set chant, "We are a set of horses." Each child then returns to his team. Alternate with A and B teams. Requests may include sets of animals and fruit.

The materials and suggested activities are presented program by program in The Teachers' Manual, Appendix B.

III. Results

A. Study I

1. Purpose. The purpose of Study I was to determine the effectiveness of the AVM Desk and the programmed instructional materials in teaching EMH children selected concepts in arithmetic.

2. Method. Experimental design, treatment, the sample and the method of analysis describe the methodological procedures.

a. Experimental design. The experimental design was primarily a Pre Post combined with a Post only, illustrated as follows:

Pre Post Combined with Post Only Design

Group	Pre (September, 1966)	Method	Post (December, 1966)
Exp. I	X	Program	X
Exp. II		Program	X
Cont. I	X	Teacher	X
Cont. II		Teacher	X

This kind of design and resulting analysis allowed for interpretation regarding the influence of the Pre Test on learning and/or on the Post Test score, in addition to determining the main effect of the experimental treatment.

Since the Pre and Post Tests (same tests) were administered via programmed instruction and since the experimental group would have more exposure to programmed instruction, there was the possibility that the exposure might influence test results without reflecting learning. Therefore, the Criterion Test was administered at the end of the treatment, individually and independently of the AVM Desk.

To determine the relative, long range, effectiveness of the two methods, the Post Test was again administered via the AVM Desk to all pupils (experimental and control) approximately one month later. The over-all testing schedule, therefore, was as follows:

Overall Testing Schedule

Group	Sept. '66	Dec. '66	Criterion Dec. '66	Post Post Jan. '67
Exp. I	X	X	X	X
Exp. II		X	X	X
Cont. I	X	X	X	X
Cont. II		X	X	X

b. Treatment. In order to insure uniform treatment in the experimental classes and in the control classes, separate workshops were held for each group of teachers. The teachers of the control groups were oriented to the objectives to be taught. These objectives were slightly different than the usual arithmetic objectives called for in the course of study for these children. The teachers were told the kind of criterion behavior expected without specification of the particular criterion measures. The teachers were not told how to teach the concepts; rather they were allowed to use their own ingenuity.

The teachers of the experimental group also attended orientation sessions. The objectives of the programs were explained, and their cooperation was sought in releasing their pupils from the classrooms for exposure to the programmed instruction. They were shown the AVM Desk and were told about the materials which were being developed for classroom use with EMH children who had completed a particular program. That is, at the time the study began, certain accompanying materials were being developed for teachers to use with children in the classrooms, after the children had been exposed to the programs. However, these materials, (games, songs, etc.) designed to reinforce the learning, were not available for the study and were not used.

The orientation sessions for both groups of teachers were held in the summer previous to the opening of school.

In September, immediately after school began, the AVM Desks were moved into unused classrooms in Schools 21 and 24. In these rooms, all of the testing took place and the experimental pupils were exposed to the programmed instruction. All of the testing and administration of the programs was done under the supervision of research assistants.

The pre testing of one group of experimental and one group of control pupils was done periodically. That is, one group of experimental pupils was pre tested on given concepts and then exposed to the concepts. Next, these pupils were pre tested on more advanced concepts and then exposed to these concepts, and so on until all of the concepts were covered. The pre testing of one group of control pupils followed a pattern similar to that of the pre tested experimental pupils.

The other group of experimental children was tested on the Post Test only. That is, they were tested only after they had been exposed to the programs. Similarly, a group of control pupils not exposed to the programs but taught the information in class, were tested on a similar schedule.

c. Sample. The sample consisted of four classes of educable mentally handicapped children, two classes from School 21 and two classes from School 24. By the flip of a coin the classes from School 21 were designated experimental while the classes in School 24 were designated as the control group. Approximately half of the pupils in each of the experimental and control classrooms were given the Pre Test. The data in Table 3 show selected characteristics of the sample chosen by this procedure. The data show that there was a tendency for Experimental Group I to have somewhat higher chronological ages and mental ages. On the other hand, this group ranked lower in terms of mean IQ (65.87).

The number of pupils reported in Table 3 is the total sample at the beginning of the study. The number of pupils reported in subsequent tables varies somewhat from table to table because pupils were not available for all testing because of illness and transfers.

Table 3 Characteristics of the Children

Group	N	MA		CA		IQ	
		$\bar{X}$	s^2	$\bar{X}$	s^2	$\bar{X}$	s^2
E_1	15	92.47	9.8	142.07	16.3	65.87	7.2
E_2	13	86.46	14.9	129.46	20.2	66.69	15.9
$E_{1\&2}$	28	89.68	12.8	136.21	19.3	66.25	6.3
C_1	17	84.76	18.8	125.35	22.5	69.18	7.9
C_2	10	86.90	16.2	123.00	21.7	71.50	7.6
$C_{1\&2}$	27	85.19	17.9	124.48	22.2	70.04	8.4

d. Method of analysis. t-tests were computed to determine the significant interaction, mean change scores and differences between means. The data generated in the three units of programmed instruction were considered separately and as a whole.

3. Results. The results are considered in this order: (a) the interaction and Pre Post Test gains, (b) the Criterion Test and (c) Retention.

a. Interaction and Pre Post gains

The results of the primary design (Pre Post combined with Post only) are summarized in Tables 4 through 7. The data from the administration of the three unit tests were analyzed as one test and separately as three tests. The data presented in Tables 4 through 7 are the error scores. Table 4 shows the results of the three unit tests combined. There is no significant interaction. There is a significant difference between the mean change scores of the experimental and control groups receiving the Pre Test. There is a significant difference between the means of randomly selected experimental and control groups receiving the Post Test only. The data and resulting analysis shows that the experimental groups did better than the control groups immediately following the treatments.

Table 4 Pre Post Combined with Post Only
Total Error Scores on the Three Units

Ss	N	Pre Test			Post Test			Change		
		$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2
E_1	12	76.1	913	77373	39.8	478	26104	36.3	435	16927
E_2	12				38.1	457	20903			
C_1	16	84.2	1348	119240	75.6	1210	101432	8.6	138	3536
C_2	9				70.8	637	48619			

Interaction $t = .79$ d.f. = 45 p = N.S.
Pre Post Change (E_1 & C_1) $t = 6.27$ d.f. = 26 $p = < .05$
Post Only (E_2 & C_2) $t = 12.20$ d.f. = 19 $p = < .05$

The results for each of the separate unit tests are summarized separately in Tables 5, 6, and 7 respectively. In no instance was the interaction significant and in all instances the means of the experimental groups were significantly different from the means (error rates) of the control groups at better than the .05 level of confidence. Thus not only did the experimental group do better on the total score on the three units combined, but they did better on each unit test.

Table 5 Pre Post Combined with Post Only
Error Scores on Unit I

Ss	N	Pre Test			Post Test			Change		
		$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2
E_1	15	15.9	239	3897	9.4	141	1557	6.5	98	785
E_2	13				8.8	114	1218			
C_1	17	15.0	255	3879	14.3	243	3559	.7	12	54
C_2	10				15.2	152	2400			

Interaction $t = .82$ d.f. = 51 p = NS
Pre Post Change (E_1 & C_1) $t = 6.50$ d.f. = 30 $p = < .05$
Post Only (E_2 & C_2) $t = 3.90$ d.f. = 22 $p = < .05$

On Unit I, a perfect score is 21. In terms of an error score it's zero. At the time of the initial testing, the mean number correct for the experimental group was 5.1 (21 - 15.9) while the mean number correct for the control group was 6.0 (21 - 15.0). The score on the post test (indicating number correct for these groups was 11.6 (21 - 9.4) and 6.7 (21 - 14.3) respectively. Thus, on unit I, the experimental group mean improved while the control group mean changed very slightly.

Table 6 Pre Post Combined with Post Only
Error Scores on Unit II

		Pre Test			Post Test			Change		
Ss	N	$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2
E_1	15	31.1	466	15920	14.8	222	4402	16.3	244	4580
E_2	13				15.7	204	3786			
C_1	17	31.6	538	17922	27.8	473	14857	3.8	65	797
C_2	10				26.9	269	8215			

Interaction t = .42 d.f. = 51 p = NS
Pre Post Change (E_1 & C_1) t = 5.70 d.f. = 30 p = $< .05$
Post Only (E_2 & C_2) t = 3.20 d.f. = 22 p = $< .05$

On Unit II a perfect score is 58. A perfect error score is zero. The post test scores (indicating number correct) on Unit II, therefore, are as follows:

E_1 (58 - 14.8) = 43.2

E_2 (58 - 15.7) = 42.3

C_1 (58 - 27.8) = 30.2

C_2 (58 - 26.9) = 31.1

The pre test score (number correct) on Unit II for groups E_1 and C_1 are very similar--26.9 and 26.4. Thus, on Unit II, as on Unit I, the experimental group mean improved considerably while the control group mean changed much less.

Table 7 Pre Post Combined with Post Only
Error Scores on Unit III

Ss	N	Pre Test			Post Test			Change		
		$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2	$\bar{X}$	ΣX	ΣX^2
E_1	12	28.2	339	12789	15.8	190	4950	12.4	149	2686
E_2	13				13.8	179	3173			
C_1	16	37.8	605	24823	33.7	539	21413	4.1	66	1692
C_2	9				31.9	287	10495			

Interaction $t = .14$ d.f. $= 46$ $p =$ NS
Pre Post Change (E_1 & C_1) $t = 2.30$ d.f. $= 26$ $p = < .05$
Post Only (E_2 & C_2) $t = 13.50$ d.f. $= 20$ $p = < .05$

On Unit III, a perfect score is 53. The Post Test scores (indicating number correct) on Unit III would be as follows:

E_1 (53 - 15.8) = 37.2

E_2 (53 - 13.8) = 39.2

C_1 (53 - 33.7) = 19.3

C_2 (53 - 31.9) = 21.1

For experimental group 1 and control group 1, the same pattern is repeated. That is, the experimental group mean improved considerably while the control group mean changed slightly.

b. The Criterion Test. The means and variances for the Criterion Test are presented in Table 8 for the Experimental Groups and Control Groups. The numbers in the table represent errors on the Criterion Test. Thus, the mean number of errors for Experimental Group 1 is 11.08. For Experimental Group 2, the mean number of errors on the Criterion Test is 10.08. Both experimental groups have a lower mean number of errors than the control groups. The difference between the experimental and corresponding control groups is significant at the .05 level for E_1 and C_1. The differences between E_2 and C_2 are not significant, (.05 level).

The total number of errors possible on the Criterion Test is 30.

Table 8 Criterion Test: Means and Variances

Group	N	$\bar{X}$	s^2
E_1	13	11.08	38.22
E_2	12	10.08	86.41
E_1 & E_2	25	10.60	61.36
C_1	17	18.12	61.40
C_2	9	13.11	32.54
C_1 & C_2	26	16.38	57.08

E_1 & C_1 $t = 2.73$ d.f. = 28 $p = < .05$

E_2 & C_2 $t = .92$ d.f. = 19 $p =$ NS

c. Retention. The results with respect to retention were measured by the Post Post Test.

The means and variances for the Post Post Test results are presented in Tables 9 through 12. Again, the mean score in the Tables are error scores. The results presented in Table 9 are those for all three units combined. The experimental groups make considerably fewer errors on the Post Post Test than do the control groups. The possible error score for all three units combined is 132. The mean number of errors for E_1 is 29.92. The mean number of errors for C_1 is 71.07. Other figures in the table can be read similarly.

On the Post Post Test, all three units combined, the means of E_1 and C_1 and E_2 and C_2 are significantly different.

Table 9 Post Post Test Three Units
Combined Error Scores

Group	N	$\overline{X}$	s^2
E_1	13	29.92	546.53
E_2	12	26.50	399.58
E_1 & E_2	25	28.28	478.92
C_1	14	71.07	640.21
C_2	6	59.00	411.00
C_1 & C_2	20	67.45	602.05

E_1 & C_1 $t = 4.24$ d.f. = 25 $p = < .05$

E_2 & C_2 $t = 3.04$ d.f. = 16 $p = < .05$

The results presented in Tables 10, 11 and 12 are the results of the Post Post Testing for Units I, II and III respectively. In all cases the means (number of errors) for the experimental groups are significantly different (.05 level) from the means of the corresponding control groups. That is, the experimental groups make fewer errors than the control groups.

Table 10: Post Post Test Unit I
Error Scores

Group	N	$\overline{X}$	s^2
E_1	13	4.00	11.38
E_2	12	4.67	11.89
E_1 & E_2	25	4.32	11.74
C_1	15	11.73	13.13
C_2	9	12.67	8.67
C_1 & C_2	24	12.08	11.66

E_1 & C_1 $t = 5.56$ d.f. = 26 $p = < .05$

E_2 & C_2 $t = 5.37$ d.f. = 19 $p = < .05$

Table 11 Post Post Test Unit II
Error Scores

Group	N	$\bar{X}$	s^2
E_1	13	12.62	83.16
E_2	12	9.92	54.58
E_1 & E_2	25	11.40	69.60
C_1	15	24.80	83.09
C_2	9	25.22	70.62
C_1 & C_2	24	24.96	78.46

E_1 & C_1 $t = 3.37$ d.f. = 26 $p = < .05$

E_2 & C_2 $t = 4.25$ d.f. = 19 $p = < .05$

Table 12 Post Post Test Unit III
Error Scores

Group	N	$\bar{X}$	s^2
E_1	13	13.31	187.56
E_2	12	11.92	120.08
E_1 & E_2	25	12.64	143.35
C_1	14	33.79	212.34
C_2	6	26.67	267.87
C_1 & C_2	20	31.65	169.39

E_1 & C_1 $t = 3.74$ d.f. = 25 $p = < .05$

E_2 & C_2 $t = 2.28$ d.f. = 16 $p = < .05$

All groups made continued improvement. The experimental groups made considerably fewer errors after the treatment (December) than did the control groups.

Even after the planned treatment ended in December, improvement continued. The reasons for the continued improvement cannot exactly be determined.

One might speculate that certain consolidation occurred. This kind of improvement has been referred to by Osgood (18) as "reminiscence." More specifically it comes close to the Ballard-Williams Phenomenon, in that the improvement in performance without practice takes place over a longer interval than in the Ward-Hovland Phenomenon. Possible explanations for this phenomenon are: (1) a process opposite to forgetting, Ballard,(1); (2) rehearsal, McGeoch (15); (3) the vacillating effects of the immediate recall upon the delayed recall, Brown (6); or (4) some combination of these three.

To further examine the gains made by all groups from December to January following the treatment, the significant difference of the mean gain scores was examined, Table 13. The mean gain scores are not significantly (.05 level) different when the experimental groups are compared to the control groups. That is, after the treatment was removed (December), all groups continued to gain up to the time of the final test (January), but there was no difference in the mean gain scores of the Experimental and Control groups. During the time of the treatment (September through December), the experimental groups' scores were superior to those of the control.

Table 13 Post Test and Post Post Test Scores of Experimental and Control Groups: After Treatment Phenomenon

Groups	E_1 & E_2	C_1 & C_2
N	25	19
Post Test: $\bar{X}$	39.12	74.47
ΣX	978	1415
ΣX^2	48856	117211
Post Post Test:		
$\bar{X}$	28.28	67.00
ΣX	707	1273
ΣX^2	31967	97255
Change: $\bar{X}$	10.84	7.47
ΣX	271	142
ΣX^2	6045	2952

$SE_{MD_E - MD_C} = 2.32$

d.f. = 35
$t = 1.02$

4. Incidental relationships. In writing and producing the programs for the AVM System, the intent of the programmers and producers was to have materials for EMH pupils whose mental ages were 8 years or below. Table 3 showed that almost all of the pupils involved in this study were below 96 months in mental age. The relationship of mental age, chronological age, and IQ, to the Post Test results is shown in Table 14. As might be expected, the highest relationship between the Post Test score and the demographic data was on mental age. Mental age shows the closest relationship to the Post Test score for the experimental groups and the control groups, separately and combined.

Table 14 Rank Order Correlations
Post Test and Selected Characteristics

Group	MA	CA	IQ
E_1 & E_2	.78	.35	.53
C_1 & C_2	.77	.69	.48
E_1, E_2, C_1, C_2	.72	.52	.16

5. Summary and Conclusions. The purpose of this pilot study was to determine the relative effectiveness of two methods of teaching selected arithmetic concepts; teachers vs. programmed instruction. Two classes (experimental) of EMH pupils were exposed to these concepts through programmed instruction (the AVM Desk). Two other EMH classes (control) were taught by the teachers of the classes. All groups improved during the experimental period September through December. The Post Test scores of the experimental groups, however, were considerably better than the Post Test scores of the control group. Continued improvement was noted one month after the experimental treatment was removed. Both the experimental and the control groups improved during the Post treatment period.

On the Criterion Test, the gains were significantly higher for Experimental Group I than for Control Group I but were not significantly higher for Experimental Group II than for Control Group II.

Incidental to the major findings it was discovered that the Post Test scores were more closely related to mental age than to chronological age and IQ. Within the limits of the design, the AVM system proved to be an effective variable in producing differential results.

B. Study II

1. Purpose. Study I demonstrated the effectiveness of programmed instruction with the AVM System in teaching educable mentally handicapped children selected arithmetic concepts. In Study I, two randomly selected classes of pupils were exposed to programmed instruction one time while two other classes were taught these concepts by their teacher. Even though these arithmetic programs were designed for educable mentally handicapped pupils of a particular age level (a relatively homogeneous group), the learning rates and learning procedures for the individuals in these groups vary considerably. That is, one pupil learns readily with one exposure to the program while other pupils seemingly need additional exposures.

The purpose of Study II was to compare the learning and retention of those EMH pupils (Experimental I) exposed to the programmed materials once with those (Experimental II) exposed two times.

2. Method. Experimental design, treatment, the sample, and the method of analysis are considered under methodological procedure.

a. Experimental design. The primary design involved in this study was a Pre Post Test of randomized matched pairs. This design may be represented as follows:

Groups	Test Administration	
	Pre	Post
Experimental I	X	X
Experimental II	X	X

The Pre Post combined with Post only design (sometimes called Solomon 4 Groups Design) was not used because there were only a limited number of conveniently located classrooms available. Also, Study I indicated that the Pre Test experience did not interact or become a variable influencing learning or retention.

Since the Pre and Post Tests (same test) were administered via programmed instruction and since the experimental group would have more exposure to programmed instruction, there was the possibility that the exposure might influence test results without reflecting learning. Therefore, the Criterion Test was administered at the end of the treatment, individually and independently of the AVM system.

To determine the relative long range effectiveness of the two methods, the Post Test was again administered via the AVM desk to all pupils (experimental and control) approximately one month later. The over-all testing schedule, therefore, was as follows:

Overall Testing Schedule

Group	Pre Jan. '67	Post Feb., Mar., Apr.	Criterion Apr. '67	Post Post May '67
Exp. I	X	X	X	X
Exp. II	X	X X	X	X

The Post Test was administered after the treatment (program exposure). For Experimental Group I the Post Test was administered once. Each unit test was administered at the completion of each of the three units. For Experimental Group II, the Post Test was administered twice. Each unit test was administered each time the child had completed exposure to the unit of instruction.

The differential exposure to tests, between Groups I and II may produce questions regarding treatment (internal validity). That is, are the differences due to the differential exposure to programs and/or the differential exposure to tests? The analysis of the results of Study I indicate that the Pre Test exposures did not produce differential Post Test results.

b. Treatment. The differential treatment in this study was the exposure to the programs. Experimental Group I was exposed once. Experimental Group II went through all programs two times.

Five AVM Desks were located in an unused classroom in the school involved in this study. Five research assistants supervised the administration of the tests and the programs and recorded all responses. The pupils came or were brought from their classrooms to the unused classroom for program exposure and testing. The Pre Testing occurred in January, 1967. Program exposure began in late January and continued through early April. The Post Tests were administered each time a child completed a unit of the program. The criterion test was administered in April. The follow-up test (Post Post) was administered in May.

c. The sample. The sample was drawn from a pool of 75 educable mentally handicapped pupils located in five special classes in one school. From this pool, twenty-eight pairs of pupils were matched on sex and mental age. One member of each pair was randomly assigned to Experimental Group II; his matchee was assigned to the other group (Experimental Group I). Table 15 shows the characteristics of the matched samples.

As can be seen from examination of Table 15, with the exception of pairs number 24 and 26 who differed nine months in mental age, pair 3 who differed by six months, and pair 27 who differed five months in mental age, all other pairs were matched within three months or less on mental age. The experimental matching resulted in means (Experimental I, 91.9 and Experimental II, 91.5) and variances (Experimental I, 275 and Experimental II, 278) which were very similar. On chronological age and IQ, the means and variances of the two groups were also similar. Thus, any achievement differences between the two groups cannot be attributed to mental or chronological age.

Before the treatment was started, the subjects were matched on sex, and mental age. Table 16 shows the extent to which this experimental matching resulted in similar groups on the Pre Test (a non-matching variable.) The scores in Table 16

TABLE 15 CHARACTERISTICS OF THE SAMPLE

Pair No.	Sex	Experimental I			Experimental II		
		MA	CA	IQ	MA	CA	IQ
1	F	74	100	74	72	122	59
2	F	79	117	68	79	118	67
3	F	112	157	71	118	153	77
4	F	63	111	57	66	133	50
5	F	111	152	73	107	161	67
6	F	67	105	67	70	100	70
7	F	86	152	57	86	121	71
8	F	90	162	56	92	126	73
9	F	100	140	71	98	158	66
10	F	95	155	61	93	143	65
11	M	78	109	72	78	109	72
12	M	76	130	58	75	106	71
13	M	57	99	58	60	86	70
14	M	113	154	76	115	164	71
15	M	81	119	68	84	131	64
16	M	114	154	74	112	151	74
17	M	114	166	70	113	161	71
18	M	111	150	74	111	158	74
19	M	91	137	66	93	125	74
20	M	98	158	62	100	146	68
21	M	102	146	70	102	141	72
22	M	84	115	73	85	121	70
23	M	106	151	70	106	165	65
24	M	74	104	71	65	105	62
25	M	83	124	67	83	117	71
26	M	117	165	72	108	149	72
27	M	95	185	56	90	163	56
28	M	101	151	67	102	138	74
$\bar{X}$		91.9	138.1	67.1	91.5	134.7	68.4
s^2		275.4	553.4	39.6	277.7	570.9	38.4

are error scores on the Units I, II, and III and on the total of all three units combined. The data in the table show that the means variances, and ranges are similar for the two groups on the separate unit tests and on total score. On all three units, however, Experimental Group II scored somewhat higher than Experimental Group I, on the Pre Test.

Table 16 Summary of Pre Test Error Scores

	Group	
	Experimental I	Experimental II
Unit I		
$\bar{X}$	13.1	15.5
s^2	13.4	6.7
Range	7-20	10-20
Unit II		
$\bar{X}$	27.6	30.0
s^2	79.2	35.0
Range	8-49	15-40
Unit III		
$\bar{X}$	32.4	34.9
s^2	140.2	154.0
Range	9-50	6-52
Units I, II, III		
$\bar{X}$	73.1	80.4
s^2	474.4	298.8
Range	24-119	31-108

3. Results.

a. Pre Post gains. The results of the primary design (Pre Post Randomized Matched Groups) using the AVM test, are summarized in Tables 17 through 20. The data from the administration of the three unit tests were analyzed separately and combined as one test. The data presented in these tables are error scores. Table 17 shows the results for the Unit I test. The maximum number of errors on Unit I is 21. The Pre Test score for Group I is 13.1. The Post Test score is 6.3. The mean gain is 6.8. The Pre Test score for Group II is 15.5 The Post Test score is 5.7. The mean gain is 9.8.

TABLE 17 Pre Post Error Scores on Unit I

Exp. I Group			Exp. II Group			Gain Exp. II over Exp. I	
Pre	Post	Mean Gain	Pre	Post	Main Gain	≤ Diff.	≤ D^2
13.1	6.3	-6.8	15.5	5.7	-9.8	85	1217

N = 28 pairs
t = 2.664

The t test of the significant difference between mean gain scores of paired groups shows that Experimental Group II gained significantly more (.02 level) than Experimental Group I. Thus, on Unit I, going through the program twice resulted in greater achievement than going through the program once.

The results for the Unit II test are presented in Table 18. The maximum number of errors possible on the unit II test is 58.

The t test of the significant difference between mean gain scores of paired groups shows that Experimental Group II gained significantly more (.01 level) than Experimental Group I. Thus, on Unit II, going through the programmed material two times did result in greater achievement than did going through the programmed material once.

Table 18 Pre Post Error Scores on Unit II

Exp. I Group			Exp. II Group			Gain Exp. II over Exp. I	
Pre	Post	Mean Gain	Pre	Post	Mean Gain	≤ Diff.	≤ D^2
27.6	12.3	-15.3	30.0	8.3	-21.7	179	3357

N = 28 pairs
t = 3.743

The results of Unit III tests are presented in Table 19. The maximum number of errors on the Unit III test is 53.

The t test of the significant differences between mean gain scores of paired groups was not significant (.05 level).

Table 19 Pre Post Error Scores on Unit III

Exp. I Group			Exp. II Group			Gain Exp. II over Exp. I	
Pre	Post	Mean Gain	Pre	Post	Mean Gain	Σ Diff.	ΣD^2
32.4	10.9	-21.5	34.9	8.4	-26.5	141	5533

N = 28 pairs
$t = 1.9794$

In Table 20 the error scores on all three tests are combined.

The t test of the significant difference between mean gain scores of paired groups was significant (.01 level). Thus, going through the program two times did result in greater achievement in terms of an overall error score.

Table 20 Pre Post Error Scores on all Three Units Combined

Exp. I Group			Exp. II Group			Gain Exp. II over Exp. I	
Pre	Post	Mean Gain	Pre	Post	Mean Gain	Σ Diff.	ΣD^2
73.1	29.5	-43.6	80.4	22.4	-58.0	405	16,725

N = 28 pairs
$t = 3.825$

b. Criterion Test. The means and variances for the Criterion Test are presented in Table 21 for Experimental Group I and Experimental Group II. The numbers in the table represent errors on the Criterion Test. The total number of errors possible on the Criterion Test is 31. The mean number of errors for Experimental Group I was 8.7. For Experimental Group II, the mean number of errors was 9.5. Both groups got over 70 percent of the items correct. However, the difference between the means of the two groups is not significant.

Table 21 Criterion Test: Means and Variances

Groups	$\overline{X}$	s^2
Exper. I	8.7	47.3
Exper. II	9.5	62.7

N = 56

t = .465

Going through the programs two times had no positive effect as far as the Criterion Test score is concerned.

c. Retention. The means and variances for the Post Post Test results are presented in Table 22 (the last two columns) for all three units combined. Again, the mean scores in the Table are error scores. The possible error score for all three units combined is 132. The mean number of error scores for Experimental Group I is 26.5. The mean number of error scores for Experimental Group II is 22.6. These Post Post means are not significantly different (.05 level).

Table 22 Retention Test (Post Post) And Pre and Post Means and Variances

Groups	Pre		Post		Post Post	
	$\overline{X}$	s^2	$\overline{X}$	s^2	$\overline{X}$	s^2
Exp. I	73.1	474	29.5	478	26.5	500
Exp. II	80.4	299	22.4	553	22.6	583

Experimental Group I (one exposure) improved from the time of the Post testing to the time of the Post Post (retention) Test (29.5 to 26.5). Experimental Group II did not change from the Post Test to the retention test (22.4 to 22.6). The reminiscence effect noted in Study I was replicated for Experimental Group I but not for the group exposed twice to the programs (Experimental Group II).

4. Conclusions. The purpose of this pilot study was to compare the learning and retention of those EMH pupils exposed to the programmed materials once with those pupils exposed two times. From a pool of 75 children located in five special classes, 28 matched pairs were selected for the study. One member of each pair was selected at random to be exposed two times. The matchee was assigned to the group exposed only once. The mean gain scores on the test on Unit I were significantly different. The group going through the programs twice gained more than the group going through the programs once. The mean gain scores on the Test on Unit II were also significantly different. The group going through the programs twice gained more than the group going through the program once. The mean gain scores on the test on Unit III were not significantly different. When the scores on all three units are combined, the mean gain scores are significantly different (.01 level). Experimental Group II gained significantly more than Experimental Group I. On the Criterion Test the difference between the means of the groups was not significant. On the retention test (Post Post), the difference between means was not significant. The reminiscence effect found in Study I was replicated for the group going through the programs once but not for the group going through the programs twice.

C. Study III

1. Purpose. In Study I, concerned with the relative effectiveness of the programmed instruction, the supervision of children, using the AVM Desk, was the responsibility of a research assistant. In Study II, concerned with the effects on learning and retention of repeating the programmed instruction, the supervision of the children was also the responsibility of a research assistant. In both of these studies, the desk was located in a room other than the classroom. It was the purpose of Study III to determine whether the AVM system could be used effectively in classrooms, under the supervision of classroom teachers.

2. Method.

a. Experimental design. The design was rather loosely structured. The greatest concern was teacher and pupil reaction. Thus, observations were made and interviews were held with the teachers.

However, in some classes Pre and Post Tests were administered. These tests were administered by the research assistant.

b. Sample. In one school, Giffen, desks were placed in two second grade classrooms composed of borderline and low average pupils and one classroom of educable mentally handicapped pupils. In another school, the desk was used for a short period of time in a classroom of five "brain damaged" children. In School 24, the desk was used in a classroom of educable mentally handicapped pupils. In this classroom, only three children, recently admitted to the class, were exposed to the program. All of the other children in this classroom had previously been exposed to the programs as part of another study.

c. Treatment. Since teachers were allowed and even encouraged to use the AVM system as they thought appropriate, the use of the AVM system varied with the specific type classroom and teacher. In some classrooms the teacher exposed all of the children to the program as part of the class schedule. In other classrooms children were only allowed to go to the desk when all of their other work was finished. In some classrooms the desk was located in front of the room, where all of the children could see a child going through the program. In other classrooms the desk was located at the back of the room, behind a screen, in such a manner that the children could not see the child at the desk.

3. Results.

a. Teaching children to use the Desk. The teachers used a variety of techniques for teaching the children to use the AVM Desk. In the EMH classroom where only three recently added children were exposed to the programs, the teacher taught one child to place the slides and tapes and that child taught the second child. Then the second child taught the third child. In the classroom of five "brain damaged" children, the teacher had the five gather round the desk for instructions. In this classroom, the teacher also had the children go through each program as a group (by use of the separate speaker rather than the head phones) and then had each child go through the program individually.

b. Teacher reaction. Study III was terminated by the end of the school year. Thus, the conclusions and reactions of teachers and pupils were necessarily limited to only about one month of exposure to the AVM system, and to completion of only the first unit of the programmed instruction. Most of the teachers had suggestions as to the kinds of concepts they would like to have programmed. One teacher suggested more concrete number concepts. Another teacher suggested multiplication and division facts. Still another teacher suggested measurement and making change.

The major advantage of the desk as seen by teachers is that a given child can be learning while the teacher is working with other children. The individualized instruction idea was frequently mentioned in the interviews.

The teachers who have used the desk in their classroom want it again. They reported that the children were eager to use the Desk.

Quotations from those of the teachers are included below:

(1) EMH Class. "The children enjoyed the programs as well learned from them. The children learned to operate the desk by themselves (set carousel tray, etc., after first time). It did not disturb the group. The children asked to go through the programs again and again. I had the lowest group start first. The "More than-Less Than" program taught the concept most adequately. I feel they learned this concept well. I would like to have the desk all the time--throughout the entire year. There was a high level of interest. I made up seat work to reinforce the concepts and also used count down, like a spelling bee, on certain concepts."

(2) Second Grade (Borderline and low average intelligence). "All the children were fascinated by the teaching machine for arithmetic. They all wanted to use it as often as possible, and did not tire of listening to the same unit many times. All of them learned the concepts presented, but I felt that the experience had the most meaning for the slowest learners. It is this group of children who need the constant repetition that this

machine makes available. I think it is an excellent method and can be used for reinforcement of as well as for introduction to various concepts. It has proved to be a valuable learning experience for both the children and myself."

(3) Second Grade (Borderline and low average intelligence). Although there was no testing of my class either before or after their use of the "Arithmetic Desk," I feel that they could not have helped but benefit from this experience with it. All stated that they liked using it--for various reasons. The race was fun; they liked writing on the screen; they liked wearing the earphones; they liked working alone. Everything but any mention of the subject matter! This, I feel, was an advantage. They didn't know they were learning. It was fun instead of work. As my group was on the C level, I found that I needed to be with the person who was using the desk for the first few minutes, to be sure they knew what to do. Often I sent one of the children who had been through the program back to watch and help whoever was using the desk. This worked well. There was no confusion caused in class by having the desk, except for the initial curiosity."

c. Pupil reaction. The teachers reported the pupils enjoyed using the desk, even those pupils who apparently learned very little from the programs. During the first exposure to the desk, some pupils were distracted, but after the novelty wore off, they settled down and learned the material.

One concern and pleasant surprise, was that, in all of the classrooms, the teacher was able to locate the desk so that the children in the classroom were not disturbed or even distracted by a child going through a program. In the EMH classroom wherein only three newly added children were exposed to the programs, (since the other children had been exposed as part of an earlier study) those children previously exposed, repeatedly asked if they couldn't go through the programs again.

d. Pupil performance. Certain selected characteristics of the five "brain damaged" children along with the Pre Post Test results for Unit I, are presented in Table 23. These children ranged in chronological age from 74-125 months.

Their mental ages ranged from 47 to 84 months, their IQs from 60 to 100. All of these children made gains. Their error scores were considerably reduced. The maximum number of errors possible on this test is 21. Several children were very close to this maximum on the Pre Test. On the Post Test they all made considerably less than half as many errors. Apparently the teacher's use of the programmed instruction (going through the programs as a group and then individually) was effective in improving performance.

Table 23 Selected Characteristics and Error Scores
"Brain Damaged" Boys (Unit I)

Subj. #	Characteristics of the Sample				Error Scores		
	Sex	CA	MA	IQ	Pre	Post	Gains
1	M	79	47	60	20	8	12
2	M	123	79	64	17	8	9
3	M	109	84	77	15	1	14
4	M	74	74	100	19	6	13
5	M	125	84	67	15	5	10
Range		74-125	47-84	60-100	15-20	1-8	9-14

The characteristics and performance of the three new children in the EMH class is summarized in Table 24. Two of these children gained little. The other child scoring the highest possible errors on the Pre Test, scored lowest on the Post Test.

Table 24 Selected Characteristics and Errors Scores:
EMH Children (Unit I)

Subj. #	Characteristics of the Sample				Error Scores		
	Sex	CA	MA	IQ	Pre	Post	Gain
1	F	109	78	72	17	13	4
2	F	118	69	58	21	6	15
3	F	114	79	69	15	12	3
Range		109-118	69-79	58-72	15-21	6-13	3-15

The characteristics and performance of ten pupils in the borderline and low average Grade 2 classroom who completed the Unit I of the programmed instruction are reported in Table 25. These pupils were selected for Pre and Post assessment because they all had mental ages of less than 90 months. Their chronological ages ranged from 88 to 111 months. Their mental ages ranged from 76 to 89 months, and their IQs from 75 to 90.

On the Pre Test, the error scores of these ten subjects ranged from 15 to 19 with a mean of 16.5. The maximum number of errors possible on the Unit I test is 21. On the Post Test, following one exposure to the programmed materials, the mean number of errors was 4.3. This difference between means is significant at the .01 level of confidence.

Examination of the individual scores and the characteristics of the sample do not lead to any explanation for the differential gains. For example, subject number 9, with a CA of 111, and MA of 85, and an IQ of 77, made the least gain, while subject number 2 with similar characteristics gained considerably more. Thus, attempts to discover a mental age, chronological age, or IQ cut off, a level for which the programs may not be appropriate, have not been successful thus far.

4. Summary and Conclusions. The purpose of this study was to determine whether the AVM system could be used effectively in classrooms under the supervision of classroom teachers. The design was rather loosely structured since the chief concern was with pupil and teacher reaction. In some classes Pre and Post Tests were administered to assess pupil gain. Desks were placed in second grade classrooms of borderline and low average children, in a classroom of five "brain damaged" children, and in classrooms of educable mentally handicapped children. Teachers were allowed to use the AVM system as they thought appropriate. As a result, different techniques were used for teaching the children how to place the slides and tapes and differential use was made of the materials. The teachers had favorable comments about the system. In particular, they mentioned the possibility of individualizing instruction. One child could use the desk to learn while

Table 25 Selected Characteristics and Error Scores: Borderline and Low Average Intelligent Children (Unit 1)

Subj. #	Characteristics of the Sample				Error Scores		
	Sex	CA	MA	IQ	Pre	Post	Gain
1	F	96	83	87	16	4	12
2	M	108	83	77	16	6	10
3	F	103	87	84	15	1	14
4	M	97	81	84	16	2	14
5	M	99	89	90	17	2	15
6	F	88	78	89	19	9	10
7	F	99	76	77	16	3	13
8	F	108	87	81	16	4	12
9	M	111	85	77	16	10	6
10	M	101	76	75	18	2	16
$\bar{X}$		101.0	82.5	82.1	16.5	4.3	12.2
s		6.5	4.4	5.3	1.4	2.9	2.8

$t = 12.937$

$p < .01$

the teacher worked with others. The teachers also had suggestions concerning what they would like to see programmed. The children had positive reactions to the use of the desk. The Pre Post Test scores showed that most pupils made considerable improvement.

D. Study IV

1. Purpose. The programmed instruction in arithmetic was designed for Educable Mentally Handicapped children whose mental ages were less than 96 months. Studies I and II demonstrated that the materials developed were effective in teaching arithmetic concepts to these children. Study III provided limited related evidence to show that low intelligence pupils

(IQs 75-90) also learned from the programmed instruction. The purpose of this study was to determine whether these programmed materials could be used with trainable mentally handicapped children.

2. Method.

a. Experimental design. The Pre Experimental design used in this study was a one group, Pre Post Test. Since the study was intended to be exploratory, teacher and pupil reactions to the programmed materials were also of concern. These reactions were assessed through unstructured observations and teacher interviews.

b. Sample. One school, containing four classes of trainable mentally handicapped children, was selected for this study.

c. Treatment. Twenty-one of the pupils in these four classrooms were given the Pre Test, were exposed to the programmed instruction, and were given the Post Test. The programmed instruction as well as the Pre and Post Test was under the supervision of a research assistant. The programs and tests were administered outside the classroom.

3. Results.

a. Teacher and Pupil reaction. Study IV was terminated by the end of the school year. Thus the study was limited to the completion of only one unit of the programmed instruction. The special class teachers had many criticisms of the programmed instruction:

"The vocabulary is sometimes not appropriate. It is 'above' the children. It needs to be simplified."

"The program steps need to be smaller. The programs need to repeat more frequently."

"Some programs are too long."

"Some concepts are too abstract."

The teachers did, however, see some advantages and future possibilities. One advantage they mentioned is that a given child can be learning at the desk while the teacher is working with other children. Furthermore, they pointed out the repetition value. That is, a child may experience the material over and over again until he has learned it. The teachers reported that the children seemed to have a positive attitude toward the programs, and using the desk.

b. Pupil performance. Certain selected characteristics of the sample along with the Pre and Post Test results for Unit I are presented in Table 26. The mean chronological age of these children was 173.3 months with a standard deviation of 50.1. The mean mental age of this group of trainable children was 59.5 with a standard deviation of 13.5. The mean IQ was 39.0 and the standard deviation was 4.9.

Very minor changes occurred from the Pre to the Post Test. On the Pre Test the mean number of errors was 17.5. On the Post Test the mean number of errors was 15.4. Most of the scores are in a positive direction, (fewer errors). This difference between means approaches significance at the .05 level of confidence. Many rival hypotheses exist for explaining this difference: the effect of the Pre Test, regression phenomenon, error of measurements, etc. Certainly the gains were minor and not comparable to those of educable mentally handicapped children.

4. Summary and Conclusions. The purpose of this study was to determine whether the programmed materials developed for educable mentally handicapped children whose mental ages were below 96 months could be used with trainable mentally handicapped children. One school containing four classes of trainable mentally handicapped children was selected for this study. The Pre and Post Test was administered to the sample. Observations were made and teacher interviews were conducted. The children made little gain on the Post Test after one exposure to the programmed material. The teachers had many criticisms of the programmed materials but thought that, with modification, this technique would be useful in teaching these kinds of children. The teachers believed that, in spite of relatively little learning, the children had positive attitudes toward the experience.

Table 26 Selected Characteristics and Error Scores of Trainable Mentally Handicapped Children (Unit I)

Characteristics of the Sample					Error Scores		
Subj. #	Sex	MA (Mo.)	CA (Mo.)	IQ	Pre	Post	Gain
1	F	70	248	39	19	19	0
2	F	70	228	39	18	10	+8
3	M	78	212	43	18	17	+1
4	M	70	218	39	16	15	+1
5	F	59	214	33	18	13	+5
6	M	32	74	43	17	19	-2
7	M	51	116	44	18	18	0
8	M	75	156	48	13	11	+2
9	M	64	169	39	18	15	+3
10	F	76	208	42	17	17	0
11	F	43	126	34	18	19	-1
12	F	69	201	38	20	15	+5
13	F	70	228	39	18	13	+5
14	M	63	206	35	20	17	+3
15	F	42	173	29	19	18	+1
16	M	71	185	41	15	13	+2
17	F	46	116	40	18	10	+8
18	M	35	91	38	16	17	-1
19	F	48	94	51	15	14	+1
20	F	58	195	31	19	18	+1
21	F	59	182	33	18	16	+2
$\bar{X}$		59.5	173.3	39.0	17.5	15.4	2.1
s		13.5	50.1	4.9	1.9	3.0	2.7

IV. Discussion

A. Phase I

During the first phase of the study the activities were concentrated on (1) developing economical audio-visual equipment, and (2) developing effective audio-visual programs for teaching selected arithmetic concepts to **EMH** children. During this phase, the project took on the added task of preparing accompanying classroom materials for teachers to use with groups of children to reinforce the arithmetic concepts and directly involve the teacher in the instructional system.

The device finally developed for presenting programmed materials to children is referred to as the Audio Visual Manipulative Desk. During the early stages in the development of the desk, visual cues and visual reinforcements were presented on a vertically placed screen while motor responses were made on a horizontally placed magnetic board. This called for continual shifting of attention from screen to magnetic board and magnetic board to screen. A breakthrough was effected by placing the screen on the working surface of the desk so that the child was able to respond directly on the screen by writing and placement of artifacts. The visual reinforcers of motor behavior, both written and manipulation, were presented directly on the response surface so that confirmation was simplified. Visual cues for the placement of artifacts reduced drastically the number of verbal directions needed.

The placement of slide trip signals on the tape presented few technical problems. However, unless signals which stop the tape player are also used, the programs would be exclusively machine paced. To partially allow for differences in response time, the programs were made pupil paced by placement of stop signals, immediately following cues for motor behavior. This feature enabled the child to complete the motor response and then reactivate the tape player. Thus, the slow child could take his time while the child with excellent coordination could proceed without an arbitrary delay. By recording new master tapes with stop signals immediately following all cues for verbal and motor responses, the programs would be completely pupil paced. Thus latency could be used as a variable in measuring learning.

While use of tape and individual slides is admirably suited to the production and editing of the programs, the program packages are bulky. After satisfactory field evaluation, transfer of the edited programs to film strips, sound track 8 mm film, video tape or some combination of these would undoubtedly reduce size and costs. Further, development of such a system would be desirable because film or video tape are admirably suited to programs written to teach time concepts, such as day, night, week, season, year, before, after, the clock, and the calendar.

Twenty-one different sequential programs were developed and organized into three units of instruction. Obviously, only a beginning has been made in programming arithmetic concepts for EMH children. Some EMH children need to learn certain pre arithmetic concepts before the current programs are appropriate. A paradigm for teaching these necessary pre arithmetic concepts using the AVM system has been prepared. Also, a beginning has been made in programming additional arithmetic concepts for EMH children. The long range goal is to teach the concepts prerequisite to the development of skills for simple budgeting, shopping, household accounting, payroll deductions, etc.

For each of the programs, accompanying illustrated materials have been prepared for teachers to use with groups in the classroom. Although these materials have been well received by classroom teachers, they have not been systematically evaluated and their effect on retention is not yet known.

For each unit of instruction a test was devised to assess the child's understanding of the arithmetic concepts included in that unit. This test administered by the AVM Desk has been shown to be effective in measuring change. When used as a Pre Test, care must be taken to avoid frustrating children. That is, experience has shown that several unit tests should not be given to children who do not understand the concepts at a point in time. Rather, if the child does not understand the concepts in Unit I, he should be exposed to Unit I (success experience) before being given the test on Unit II. A calculated risk in the use of any Pre Test is that the emission of an incorrect response in terms of one trial learning, may introduce interferences in later learning.

B. Phase II

During the second phase of the study, four separate studies were designed to evaluate the programmed materials.

Study I demonstrated that the AVM system was an effective variable in producing differential results. That is, those children exposed to the programmed materials gained more than those children taught by conventional methods. The accompanying materials for teachers to use with groups of children were not used in this study. Therefore, one can only speculate as to whether use of the accompanying materials would enhance the differences found, improve retention, or even pose unforseen problems.

This study was limited in that the programmed instruction was supervised by research assistants and the children were taken to a room, other than a classroom, for exposure to the programs.

Study II demonstrated that going through the programs twice did produce higher Post Test scores than going through the programmed materials one time. However, this difference did not hold up on a retention test three weeks later.

The design used in this study was a matched pairs, Pre Post Test design. The member of the pair, selected for two exposures, was determined at random, at the beginning of the study. Thus, half of the children who did well the first time (made few errors) as well as half the children who did not do well the first time (made many errors) repeated the programs a second time. One serious limitation of this design was that the high scoring children could not be expected to improve since they were near the test ceiling initially. Also, in exceptional cases, the pupils were resistant to a second exposure. This design did not help in the identification of pupils who might profit from multiple program exposure.

Study III demonstrated that the AVM System could be used effectively in classrooms under the supervision of classroom teachers in a variety of settings.

One of the most encouraging outcomes of this study was the eagerness with which the teachers accepted this equipment (and the programs) and the many novel circumstances they created to use it effectively. All of the teachers asked to have the materials again next year.

Study IV demonstrated that the programs of Unit I developed for educable mentally handicapped children were inappropriate for trainable mentally handicapped children, when these children were exposed once. Despite the fact that the children made relatively little gain their attitudes toward the experience were positive. One can only hypothesize as to why these children eagerly looked forward to the experience. Perhaps it was the attractiveness of the colored slides of familiar objects. Perhaps it was the manipulation of attractive three dimensional objects. Perhaps it was some positive feelings in controlling some of the pacing. Perhaps it was the auditory stimulus or perhaps it was some combination of these or other factors.

Regardless of the reason, the reactions of the children and the teachers were encouraging. Although the teachers had many criticisms of the programs, they all thought, that with program modification, the technique would be useful in teaching concepts to those kinds of children.

V. Conclusions, Implications, and Recommendations

A. Conclusions

The conclusions with respect to the effectiveness of the AVM System in teaching arithmetic concepts to educable handicapped children are presented for Phase I in terms of the equipment and the programs, and for Phase II, for the four field studies.

1. AVM Equipment. In summary, the AVM Desk was developed and was effective in presenting the audio-visual manipulative programmed lessons to educable mentally handicapped children. The equipment is reliable and simple enough to be serviced by an electronic technician. The cost of commercially producing the desk is estimated to be less than five hundred dollars.

2. AVM Programmed Materials. The twenty-one sequential programs devised to teach arithmetic concepts to educable mentally handicapped children were effective. Children learned arithmetic concepts and retention of learning was demonstrated.

3. Study I. Selected arithmetic concepts were taught to EMH children by the AVM system (Experimental) and by competent and experienced teachers (Control). Both groups learned. The gains of the Experiment Group were significantly greater than the gains of the Control group. One month after the treatment ended, both groups had somewhat higher scores on the test of retention. The differences between the Experimental and Control Groups remained significant. Post Test scores of both groups were more closely related to mental age than to chronological age and IQ.

4. Study II. Twenty-eight matched pairs of EMH children were randomly assigned to two treatments (one exposure versus two exposures to the AVM lessons). The group exposed to the AVM lessons twice learned significantly more than the single exposure group. Single vs. double exposure to the programs failed to result in significant differences on the Criterion Test or on retention (Post Post Test). Experimental Group I (one exposure) improved from the time of the Post testing to the time of the Post Post (retention) Test. Experimental Group II did not change from the Post Test to the Retention Test.

5. Study III. Teachers found that individual pupil use of the desk in the classroom fitted smoothly into the regular instructional program. Very little teacher time was required in supervision because most children operated the desk independently. Teacher and child evaluation was most positive. Limited Pre Post evaluation indicated that the pupils learned the programmed concepts.

6. Study IV. Trainable mentally handicapped pupils learned very little in one exposure to the programs of Unit I. The teachers recommended that more appropriate programs be prepared for their children.

B. Implications

The implications from the findings of this study lend support to previous implications resulting from other studies of programmed instruction and learning. That is, programmed instruction will undoubtedly teach more children a greater amount of concepts more effectively. At a general theoretical level, the implications are: (1) The sequence of instruction beginning with physical representation of the properties of things (in this study numerical properties) and building progressively to symbolic representation, linking concrete manipulative behavior to abstract symbolic behavior, is effective in teaching children. (2) A multisensory approach (doing, seeing, and listening) allows for careful control of input so that distractors are minimized and attention is maintained. (3) The extent to which instruction increases the number of initial correct responses, to that extent interference is reduced in subsequent learning. (4) Focusing on the crucial rather than the irrelevant discriminations allows for mastery of the desired concepts.

Within this framework of general implications the specific implications of this study are: (1) More simple and more complex pre-arithmetic and arithmetic concepts need to be programmed. (2) The procedure and system may also be effective in teaching other kinds of pupils arithmetic concepts. (3) The procedure and system may be effective in the teaching of other visual and auditory discriminations as are needed in early reading programs. (4) Other evaluative studies need to be conducted to determine (a) the relative effectiveness of the various components of the system, and (b) the effectiveness of the system when used under different conditions and procedures.

C. Recommendations

1. AVM Equipment. It is recommended that (a) sound track 8 mm film and video tape be adapted for presentation of the programs in the AVM Desk, (b) monitoring techniques be developed for the assessment of pupil response, and (c) a feasibility study in adapting the programmed materials for computer assisted instruction be initiated.

2. AVM Programmed Materials. It is recommended that (a) programming of arithmetic concepts be continued, (b) programs be developed to teach the visual and auditory discriminations necessary for the teaching of reading, and (c) the taped programs be made completely pupil paced so that studies of latency response may be initiated.

3. Study I. In field evaluation of programs similar to Study I, it is recommended that the evaluators record pupil responses on mark sense cards to make item analysis of behaviors feasible.

It is recommended that the effectiveness of the classroom activities in teaching arithmetic concepts be studied in an extension of the design of Study I. For example, by using six groups and an analysis of variance one could determine the relative effectiveness of the programmed instruction, accompanying materials, and conventional methods.

Using randomized groups and a Post Test this design might be schematized as follows:

	Groups	Post Test
1.	Programmed instruction only	X
2.	Conventional instruction only	X
3.	Accompanying materials only	X
4.	Programmed instruction and accompanying materials	X
5.	Conventional instruction and accompanying materials	X
6.	Conventional instruction and programmed materials	X

4. Study II. It is recommended that the design of Study II be refined so that the main sample be comprised of pupils who make many errors on the Post Test of a unit. Matched pairs would be randomly assigned to experimental and control groups. The experimental subsample would be exposed to the programs a second time while the control subsample would receive no additional instruction.

5. Study III. It is recommended that the use of the AVM System in a school library or material laboratory setting be evaluated. A collateral problem would be teacher prescription of programs to be administered for remediation.

6. Study IV. It is recommended that (a) the AVM System be evaluated in a variety of classrooms for at least a semester, and (b) when the system is used in a class of hyperactive children, the system be effectively isolated within the classroom.

VI. Summary

The problem, purpose, methods, results, and conclusions are considered briefly in the summary.

A. Problem

When children enter the first grade, certain assumptions are made concerning the concepts that they have developed previous to entering school. And, as they continue through school, each teacher continues to make certain assumptions regarding the concepts that children have learned in the preceding year. These assumptions are often incorrect for all children and in particular are incorrect for handicapped children. Because of their special handicaps they may proceed at a different rate of growth than the average child; they may learn new concepts more slowly; and assumptions regarding the concepts they possess, as they continue in school, become more and more precarious.

Even in special classes for the educable mentally handicapped children, there is a wide range in the concepts grasped. Thus, in spite of the fact that class size is reduced, because of the nature of EMH children, a considerable amount of the teaching time is devoted to teaching a given concept to a very few, or to only one child at a time.

It has been estimated by Mayo (14) that there are currently 1,250,000 mentally retarded school age children and that only about 250,000 of these children are enrolled in special classes wherein because of reduced size, special teacher competence, and the homogeniety of the group, some attention may be given to individual concept development. However, the other four-fifths of the mentally retarded school age population, not in special classes, may not be expected to receive the individual attention necessary to develop these concepts.

One area in which help may be found for teachers in their attempt to deal with individual differences is programmed instruction. To have programmed materials available which are able to identify whether children know certain concepts and to have programmed materials available to teach handicapped children the concepts they lack, should be an asset to the majority of these children, regardless of whether they are located in special classes or in regular classrooms.

B. Purpose

The overall purpose of this study was to develop audio-visual equipment and materials for teaching educable mentally handicapped children arithmetic concepts and to evaluate the developed programmed instructional materials.

During the first phase of the study the activities were devoted to accomplishing the first purpose, developing audio-visual equipment and materials. More specifically, this purpose was: (1) to develop economical audio-visual equipment, (2) to develop audio-visual programs applicable for use with economical equipment for teaching selected arithmetic concepts to EMH children.

It was realized as the programming progressed, that if these programmed materials were to be efficiently used in classrooms by teachers, it would be advantageous to prepare accompanying materials related to classroom activities for teachers to use with groups of children. Thus, the project took on the added task of preparing acoompanying materials as well as a description of their use.

During the second phase of the study the activities were devoted to accomplishing the second purpose, evaluating the developed programmed materials. Specifically, this purpose included: (1) comparing EMH students taught by conventional methods with those taught via programmed instruction, (2) comparing EMH students exposed to the programs once, with those exposed two times, (3) determining the effects on pupil performance of teacher use of the instructional system, (4) determining the effectiveness of selected programs in teaching the trainable mentally handicapped.

C. Method

1. Development of Equipment. The development of economical audio-visual equipment was undertaken by the Albany Public Schools before the grant was received and continued during the first phase of this project.

Several devices and combinations of devices were used during the trial period including the Audio-Graphic, manufactured by the Graflex Corporation and the Teleguide, manufactured by the LaBelle Corporation.

The device finally developed and in use in this project is referred to as the Audio-Visual Manipulative Desk. Inside the desk is a Kodak cartridge slide projector from which visual information is presented on a horizontally placed screen and a loop tape player (Tape-Dek II) which transmits audio messages to the child either through a speaker or through earphones. The child manipulates objects on the response surface (the screen) or writes on the surface using a water soluble ink felt pen. The AVM Desk can be either pupil paced or program paced.

In the programs for the AVM Desk (developed to date) visual and auditory reinforcement is used. The programs are pupil paced for all frames which involve manipulation.

2. Development of Audio-Visual Materials. Programmed instructional materials for teaching EMH children skill sequences in arithmetic were developed. Twenty-one different sequential programs are now available on such topics as sets, elements, counting and enumeration, more-than, less-than, ordinals, etc. The twenty-one programs are organized into three units of instruction. Unit I, Sets and Matching, is composed of three programs. Unit II, One, Two, Three, is composed of ten programs. Unit III, Zero, Four, Five, is composed of eight programs. These programs are primarily designed for EMH children whose mental ages are below eight years.

The sequence of instruction begins with physical representation of the numerical property of things and builds progressively to symbolic representation, i.e., an arithmetic concept is developed first with objects, then pictures, and finally numerals. A wide variety of stimuli is presented to the child, without presuming any ability on his part to read. The sequence links together the concrete manipulative behavior in which the EMH child has some facility with the abstract symbolic behavior with which he has difficulty. In a sense, it is a means of connecting, doing, seeing, and saying, into a highly organized multisensory learning experience.

3. Development of Assessment Devices. For each of the three units of instruction a test was devised to assess the child's understanding of the arithmetic concepts included in that unit. The tests are programmed and administered by the AVM Desk. The tests can be administered initially to determine the child's level of understanding and can be administered again following the exposure to the Units of Instruction, to assess learning.

Another kind of test, referred to as the Criterion Test, was also developed. This test was designed to measure whether a child knows the concepts included in all three units. This device is not programmed, nor is it associated with the AVM Desk. It is administered individually by an examiner and takes approximately ten minutes.

4. Accompanying Materials for Teachers. For each program produced, accompanying instructional materials have been prepared for teachers to use with groups in the classroom. That is, after children have been exposed to the programmed instruction, these materials (games, songs, etc.) can be used to reinforce the learning and thereby improve retention.

Also, a manual for Teachers has been prepared. This manual includes a curriculum guide for each program. The manual describes the objectives of each program, the operation of the AVM Desk, and the uses of the three-dimensional objects. The manual describes in detail the programmed materials. Also, it describes the classroom activities which reinforce programmed learning.

D. Results and Discussion

1. Study I. The purpose of Study I was to determine the relative effectiveness of the programmed instruction in teaching selected arithmetic concepts to EMH children. Two classes (experimental) of EMH pupils were exposed to these concepts through programmed instruction (the AVM Desk.) Two other EMH classes (control) were taught by the teachers of the classes. All groups improved during the treatment period, September through December. The Post Test scores of the experimental groups, however, were considerably better than the Post Test scores of the control group. Continued improvement was noted on a

follow-up testing one month after the experimental treatment was removed. Both the experimental and control groups improved during this Post treatment period. Incidental to the major findings it was discovered that the Post Test scores were more closely related to mental age, than to chronological age and IQ.

2. Study II. The purpose of this study was to compare the learning and retention of these EMH pupils exposed to the programmed materials once with those pupils exposed two times. From a pool of 75 children located in five special classes, 28 matched pairs were selected for the study. One member of each pair was selected at random to be exposed two times. The matchee was assigned to the group exposed only once. The mean gain scores on the tests on Units I and II were significantly different. The group going through the programs twice gained more than the group going through the programs once. The mean gain scores on the Test on Unit III were not significantly different. When the scores on all three units are combined, the mean gain scores are significantly different (.01 level). Experimental Group II gained more than Experimental Group I. On the Criterion Test, the difference between means was not significantly different. On the Retention Test given three weeks after termination of the treatment, the differences between means was not significant.

3. Study III. The purpose of this study was to determine whether the AVM System could be used effectively in classrooms, under the supervision of classroom teachers. The design was rather loosely structured since the chief concern was with pupil and teacher reaction. In some classes Pre and Post Tests were administered to assess pupil gain. Desks were placed in second grade classrooms of below average children, in a classroom of five "brain-damaged" children, and in classrooms of educable mentally handicapped children. Teachers were allowed and even encouraged to use the AVM System as they thought appropriate. As a result, different techniques were used for teaching the children how to place the slides and tapes and differential use was made of the materials. The teachers generally had favorable comments about the system. In particular, they mentioned the possibility

of individualizing instruction. One child could use the desk to learn while the teacher worked with the others. The teachers also had suggestions concerning what they would like to see programmed. The children had positive reactions to the use of the desk. The Pre Post Test scores showed that most pupils made considerable improvement.

4. Study IV. The purpose of this study was to determine whether the programmed materials for educable mentally handicapped children, whose mental ages were below 96 months, could be used with trainable mentally handicapped children. One school containing four classes of trainable mentally handicapped children was selected for this study. The Pre and Post Test was administered to the sample. Observations were made and teacher interviews were conducted. The children made little gain on the Post Test after one exposure to the programmed material. The teachers had many criticisms of the programmed materials but thought that, with modification, this technique would be useful in teaching these kinds of children. The teachers believed that, in spite of relatively little learning, the children had positive attitudes toward the experience.

E. Conclusions, Implications and Recommendations

1. Study I. Within the limitations of the design, Study I demonstrated that the AVM System was an effective variable in producing differential results. In this study, the supervision of the programmed instruction was under the control of research assistants in a room other than the classroom and the classroom reinforcement activities were not used. Additional evaluative studies need to be conducted to determine the effectiveness of these variables.

2. Study II. This study demonstrated that going through programs twice did produce higher Post Test scores than going through the programmed material once. However, this difference did not hold up on a retention test three weeks later. Both the experimental and control groups (matched pairs) were composed of children who scored high on the Pre Test as well as those who scored low. The ceiling effect of the test may have masked the differences between

groups. An additional study, selecting only low scoring pairs, is needed to ascertain the effects of repeated exposure on retention.

3. Study III. Study III demonstrated that the AVM system could be used effectively in classrooms under the supervision of classroom teachers, in a variety of settings. The results suggest that the AVM System is suited for classroom use. It is recommended that the System be evaluated systematically, for longer periods of time.

4. Study IV. This study demonstrated that programs developed for educable mentally handicapped children were inappropriate for trainable mentally handicapped children, when these children were exposed once. In spite of the relatively little learning, the children had positive attitudes toward the experience. Teachers and research assistants concerned with the study indicate that the technique has possibilities. However, separate programs need to be developed for this type of pupil.

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APPENDIX A

THE AVM DESK

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I. Introduction

The AVM Desk is basically a convenient and comfortable arrangement to permit subjects, usually children, to partake of an individual audio-visual-manipulative experience. The first construction drawing of the desk is presented in Figure A-1; the second construction drawing of the desk is presented in Figure A-2. The slightly sloping top has a translucent screen for slides projected from the interior, upon which objects may be placed, rearranged, or removed, or lines drawn and erased. The audio part of the program is available from a loudspeaker but headphones are normally used.

Typically, the subject is asked to operate a switch which applies power to both the slide projector and tape player. The audio output presents a program of instruction, during which the slides are changed at appropriate times. On some occasions the child is asked to respond by some particular manipulation, and in order to insure sufficient time for completion, the tape player shuts itself off at these points until it is deliberately restarted by the operation of a second switch or button. At the end of the program, the subject is asked to turn off the power switch.

Equipment for playing and recording magnetic tapes which includes the ability to initiate slide changes and "off," or "stop" signals, is commercially available but is expensive, bulky, and uses tapes which must be threaded between reels, a considerable inconvenience.

In May, 1966, the projectors used were Kodak Carousel model 800, and seemed to produce no problems. The tapes were recorded and played back by RCA Model 3YD 11 stereo tape recorders designed for home entertainment use. These recorders use the RCA tape cartridge, now becoming obsolete, in which there are two small reels holding about 400 ft. of tape. Both machines had been modified. One had the voice on one of a stereo pair of tracks and used the other for slide change signals. No stop signals were used, and the programs used with this player had pauses whose duration was estimated to be correct, at the appropriate places. The other equipment had an extra playback head added, and one of the four stereo tracks which would have been used had the cartridge been turned over was used for "stop" signals. A special recording box with buttons for "stop" and "slide trip" was provided.

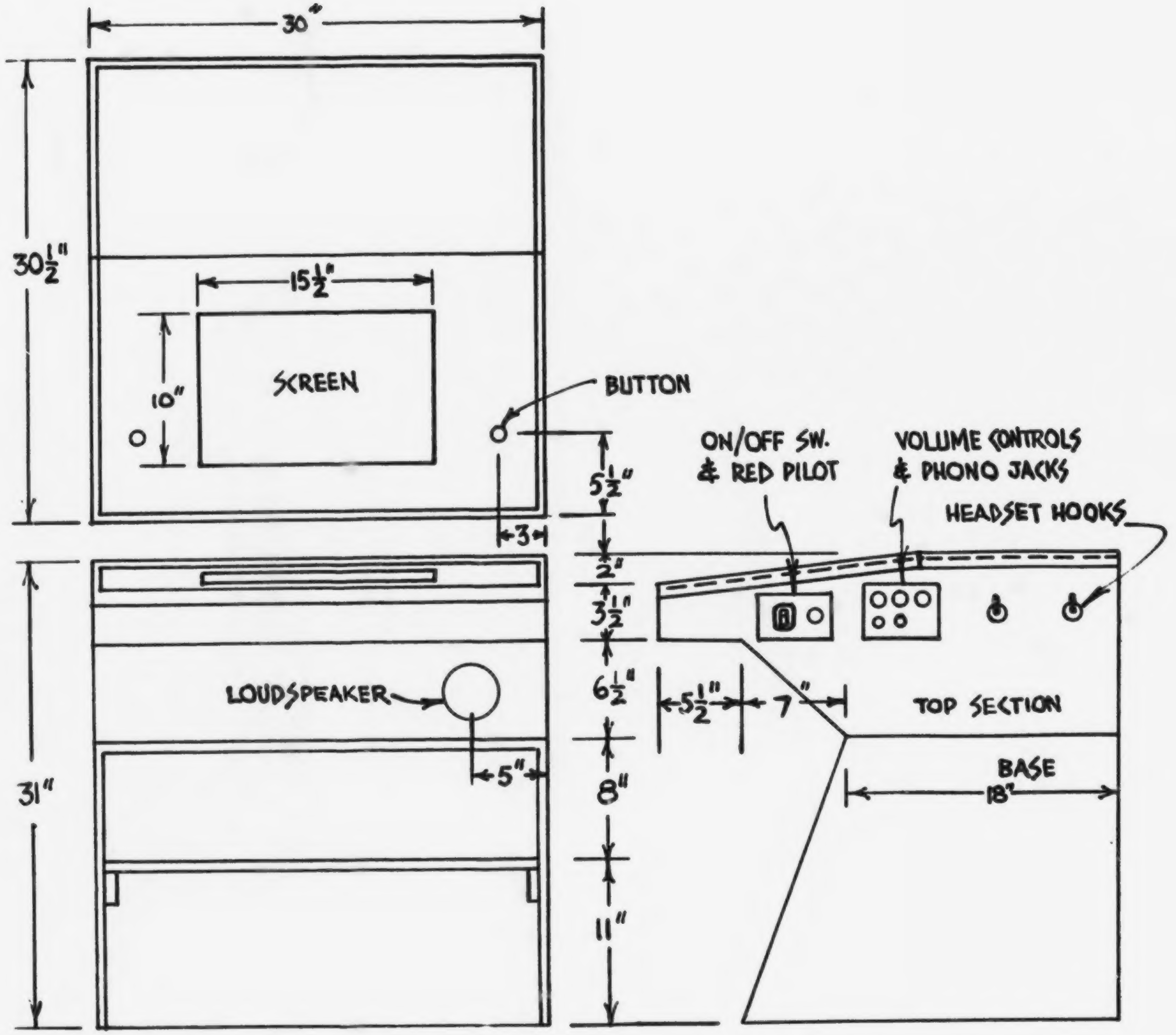


Figure A-1. FIRST CONSTRUCTION DRAWING OF DESK

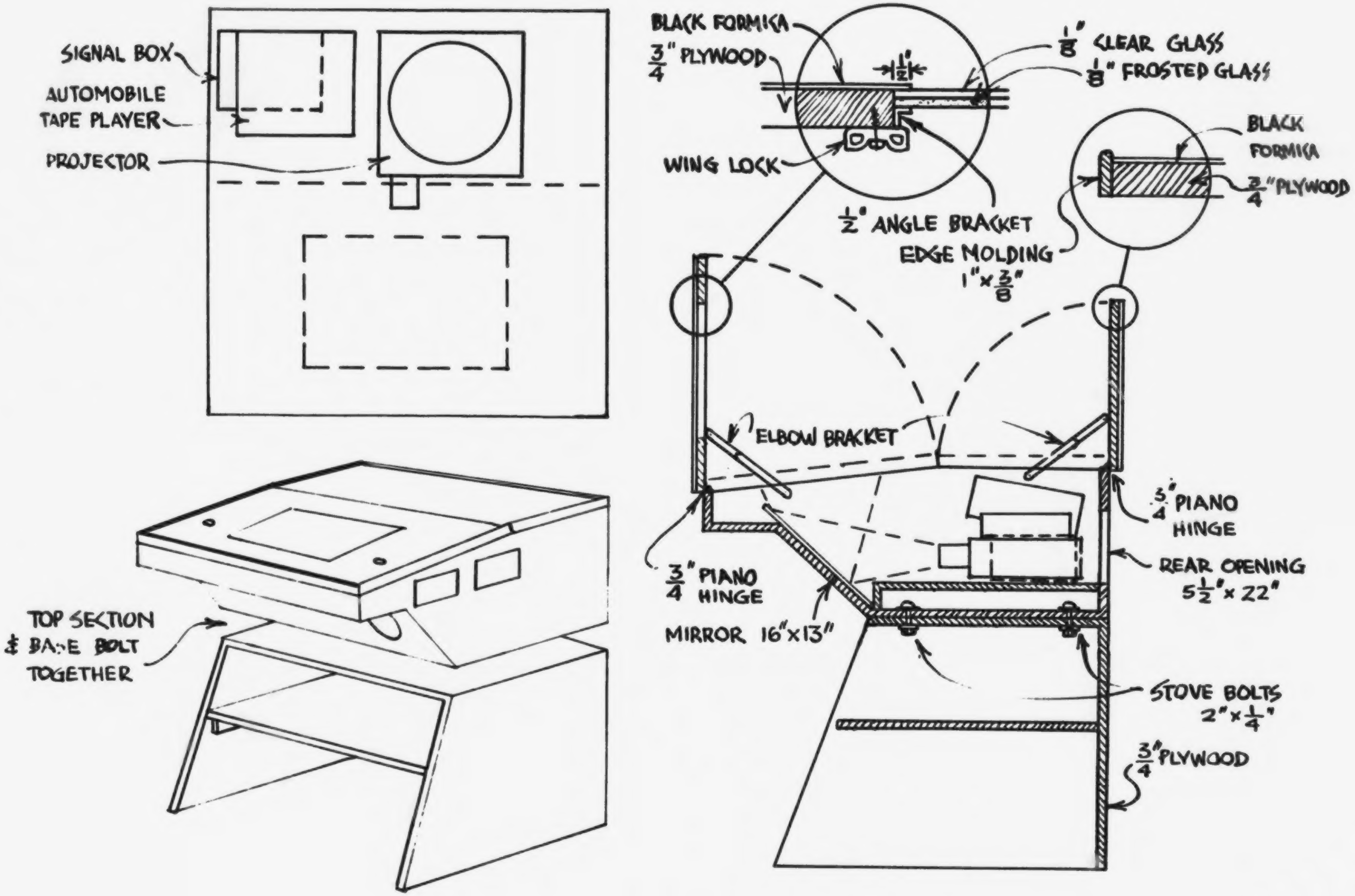

SIGNAL BOX
AUTOMOBILE TAPE PLAYER
PROJECTOR
TOP SECTION & BASE BOLT TOGETHER
BLACK FORMICA
$\frac{3}{4}$" PLYWOOD
$\frac{1}{2}$"
$\frac{1}{8}$" CLEAR GLASS
$\frac{1}{8}$" FROSTED GLASS
WING LOCK
$\frac{1}{2}$" ANGLE BRACKET
EDGE MOLDING $1" \times \frac{3}{8}"$
BLACK FORMICA
$\frac{3}{4}$" PLYWOOD
ELBOW BRACKET
$\frac{3}{4}$" PIANO HINGE
$\frac{3}{4}$" PIANO HINGE
REAR OPENING $5\frac{1}{2}" \times 22"$
MIRROR 16"x13"
STOVE BOLTS $2" \times \frac{1}{4}"$
$\frac{3}{4}$" PLYWOOD

Figure A-2. SECOND CONSTRUCTION DRAWING OF DESK

At that time neither of these equipments was operating properly. There were many difficulties. The amplifiers, originally vacuum tube types, had been replaced by solid state amplifiers. The temperature inside the recorders would gradually rise, in use, to very high values, since the drive motor and power transformer were poorly ventialted, putting the amplifiers, including the voice channel, out of operation. The signals which were recorded to produce slide trips or stops were merely 60 Hz. voltages from a transformer winding. The amplifiers and tape heads were very insensitive to such a low frequency, however, and what came out upon playback was mostly higher harmonics, and with little energy content. New tape players of the same model were no longer available, and the presence of the extra head increased the difficulty of inserting tape cartridges.

As a temporary expedient, the temperature problem was obviated by removing the transistorized amplifiers from inside the case to an external position where there was little temperature rise.

The unit using 3 channels was put into operating condition, but both units occasionally produced spurious slide trip signals and sometimes failed to trip slides at proper points. The reasons were complex but trouble resulted in general from lack of control of the amplitude and duration of the recorded signals, sensitivity to interfering noise, variation of sensitivity with temperature, and even imperfect erase of previously recorded signals.

II. Desirable System Characteristics

For long term use in classrooms as well as in the laboratory, the following system characteristics were thought to be desirable:

A. Each desk should have a playback unit only, so accidental erasures would be impossible.

B. All recordings would be made by a standard tape recorder, not directly associated with a playback desk.

C. The durations of the recorded control signals should be uniform and not controlled by the operator.

D. The simplest possible tape threading

arrangement was desired, with a tape cartridge the first choice.

E. If possible, recordings should be made on one pair of stereo tracks only.

F. Conventional equipment should be used wherever possible to simplify maintenance and service procedures.

III. The Tape Player

The recent introduction of a low cost unit for playing stereo tapes in automobiles provided the basis for a system satisfying most of the above requirements. Auto tape players are of two general types, both of which use endless loop cartridges of quarter inch magnetic tape of similar design. The "eight track" system, however, divides the tape into eight sections, each less than 1/32 inch wide. A double tape head is then physically moved to one of four positions, at each of which there is a stereo program recorded on the tape. The four track system has capability for only half the program material per foot of tape, but is less critical of mechanical tolerances and more nearly compatible with available recording equipment. Some of the features of a typical auto 4 track stereo player follow: Tape speed--3 3/4 inches per second, Tape length--to 300 or 600 feet depending on cartridge size, Maximum program time--16 minutes for 300 foot cartridge for 1 stereo pair, Outputs--for 2 or 4 loudspeakers, Program choice--by turning knob which moves tape head 1/16 inch. It should be noted that lubricated type tape should be used to prevent binding.

The use of such a player unit in an AVM desk involves a number of considerations, some of which may be contrasted with the use of RCA cartridge players. The RCA cartridge, as mentioned previously, is really a pair of spools, pre-threaded with tape and almost completely enclosed. Operation is more or less conventional in that in most players the forward, fast forward, and rewind functions are included. Endless loop cartridges players, however, are designed to operate forward when the cartridge is plugged in, and no reverse or fast forward is available. This means that a program, once begun, must be run all the way to the end at normal speed to reach its beginning again. This should not be a disadvantage in normal operation (indeed, freedom from the necessity to rewind is an advantage) but it may occasionally be a nuisance.

Although two stereo channels are available on a particular 4 track tape, only one is actually usable. There are two reasons for this. Most recording equipment uses a pair of heads fixed in position which are adjacent to the first and third quarters of the tape passing by. After the spool is empty, the tape is not normally rewound, but turned over. The second and fourth quarters now pass the same pair of heads but in the opposite direction. In a cartridge player, the pair of heads is moved physically but the direction of tape motion is always the same. There is therefore compatability for one stereo pair, but not for both. Even if a recorder were available with two head positions, there would still be a practical difficulty. At a point almost exactly in the center of the program, timewise, it would be necessary to switch the head position to play back the second half of the program. Although automatic means for doing this are available, a difficult problem exists in the recording process and it seems much simpler to merely leave one pair of tracks unused and to limit programs to 16 minutes, or 32 minutes with larger cartridges.

Although auto tape players are designed for use with an auto battery as a power supply, several manufacturers offer for sale a 120v ac to 12 v dc converter unit to permit the tape players to be used in the home. Both player and converter are compactly built however, and a third unit is necessary to house the control equipment. In the systems now in use, the third unit is fastened directly to an appendage to the power unit (converter) and occupies only about 30 cubic inches.

IV. Procedures for Recording Programs on Tape

The general operating procedure for a system using an automobile tape player in an AVM desk can be described as follows: A stereo tape recorder is used to record the voice program on one channel. While control signals may be simultaneously recorded, it is usually easier to introduce them after a program has been completely recorded and any corrections needed have been made. The control signals are short tone bursts, actuated by operating button switches. It is therefore best to use a tape recorder which permits simultaneous recording on one channel of a stereo pair while monitoring the other. At the appropriate points in the program, one or the other of two buttons is operated. These are labeled STOP and SLIDE TRIP. They each produce a tone burst about 1/3 second long regardless of the duration of time the switch is depressed. The STOP tone burst is at about 250 cycles per second, and the SLIDE TRIP at about 2000 Hz. These tones are then recorded on the tape at a high level (close to saturation.)

The recorded program, or a copy of it, is then cut from the tape supply spool, and, using the proper procedure, loaded onto an endless cartridge spool. The steps in doing this were as follows:

Remove the supply reel. Take the reel from the take-up spindle on the recorder and without turning it over, place on the supply spindle.

Place an empty reel on the take-up spindle. Wind the recorded tape fast forward in the normal manner.

Place an empty cartridge reel on the supply spindle. Rewind--oxide side of tape facing out. Fold inner tape, so that this can later be disengaged easily.

Remove 18" tape from outer circle.

Remove 9" tape from inner circle.

Splice A. cut
  B. tape
  C. trim

Load cartridge. With left hand, or finger, release spring brake. With right hand, pull tape from center until slack is taken up. Place tape around guide posts.

Place wire.

Place cover and screw.

When this cartridge is then played in an auto type player installed in the AVM desk, the audio program is available from a loudspeaker or one or two sets of headphones each with individual volume control. The second channel, which is normally connected to a second loudspeaker, goes instead to a pair of electrical filters which separate the high and low frequency tones. The filtered tones then go to circuits which, in effect, count the number of cycles. If only a few cycles are counted, this circuit assumes that the disturbance was a spurious noise and does nothing. If a sufficient number are counted, the SLIDE TRIP circuit closes a relay contact momentarily which advances the slide change mechanism of the slide projector.

If a stop signal of sufficient duration is recorded the action is similar up to the point where a relay contact is momentarily closed. In this case, however, a second larger relay is caused to operate and to lock itself in the closed position. This disconnects the power to the tape player, turning off its amplifiers and motor, and the tape coasts to a stop. Mounted on the desk surface there are two illuminated push buttons, which are now energized, and glow. Depressing either of these buttons momentarily will open the larger relay, blacking out the buttons and restarting the amplifiers and tape drive motor. A block diagram of the Playback System is shown in Figure A-3. A block diagram of the Tone Burst Generator used to produce the tones for recording signals is shown in Figure A-4.

V. Technical Aspects of the System

A. Recording Equipment

The tape recording equipment currently in use consists of a Sony model 200 stereo recording system and a Sony model 350 stereo tape desk. The voice program is recorded using standard techniques on channel 2 using either the recorder or the desk. The speed used is 3 3/4 i.p.s. When the program has been satisfactorily recorded, it is then played back and simultaneously, control signals are recorded on channel 1 at the appropriate points. This can also be done with either machine. The resulting tape is considered a master, and used to produce copies. With two stereo machines available, one is used to play back, and the other to record a (two channel) copy of the master. The copying may be done at 7 1/2 i.p.s. to save time. The copy, on lubricated tape, is then cut a few inches beyond the end of the program and rewound on to an empty endless cartridge spool using the technique described above.

The recording equipment is not particularly special, and nearly any brand of stereo recorder would be satisfactory provided that it permitted recording on one channel while listening on the other. The only difficulties experienced so far have been connected with the problem of locating particular spots on the master tape. Unfortunately the tape "footage" counters really count revolutions of the take up spool, so the apparent length of a program depends on whether it is

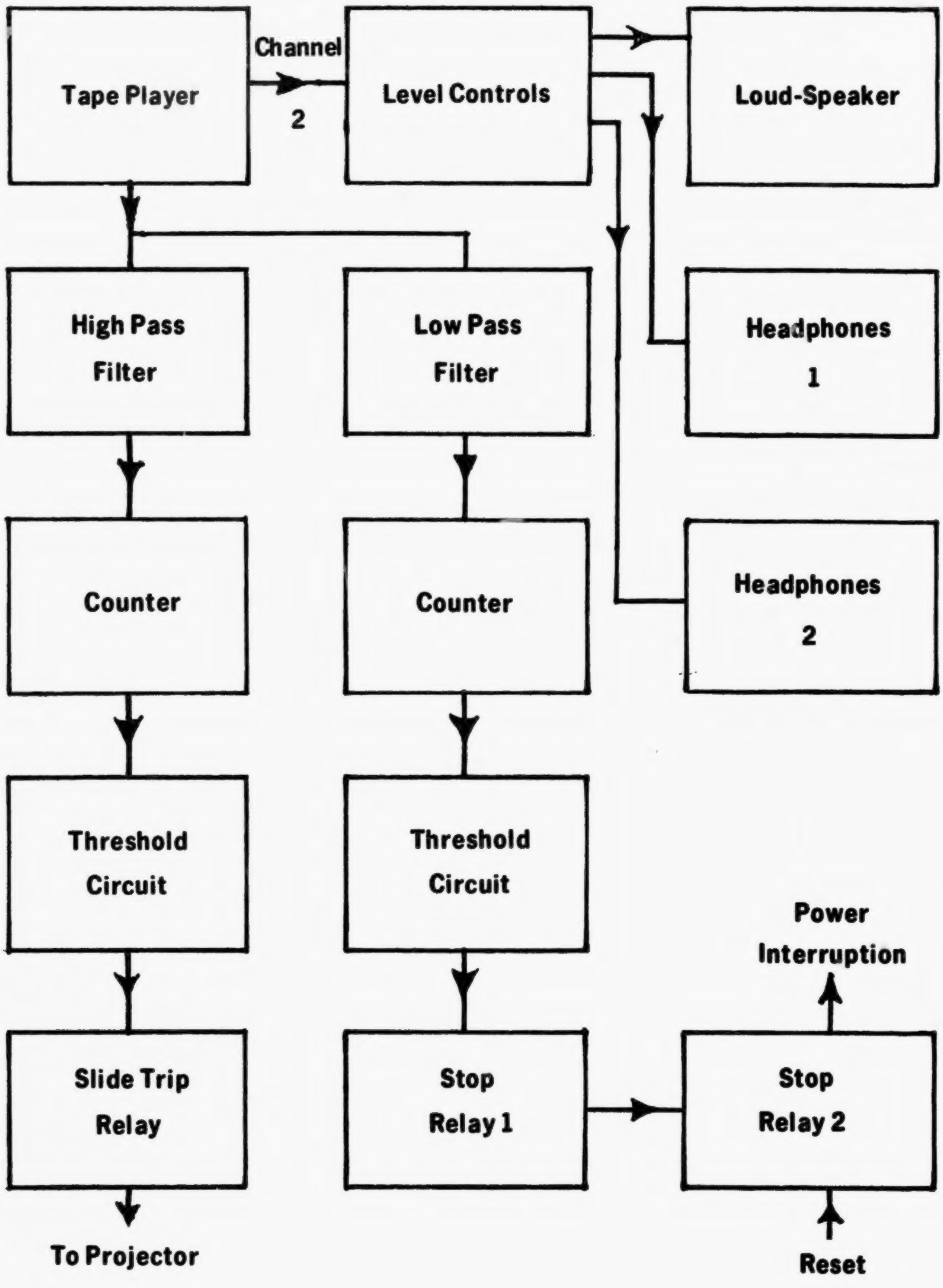


Figure A-3. BLOCK DIAGRAM OF THE PLAYBACK SYSTEM

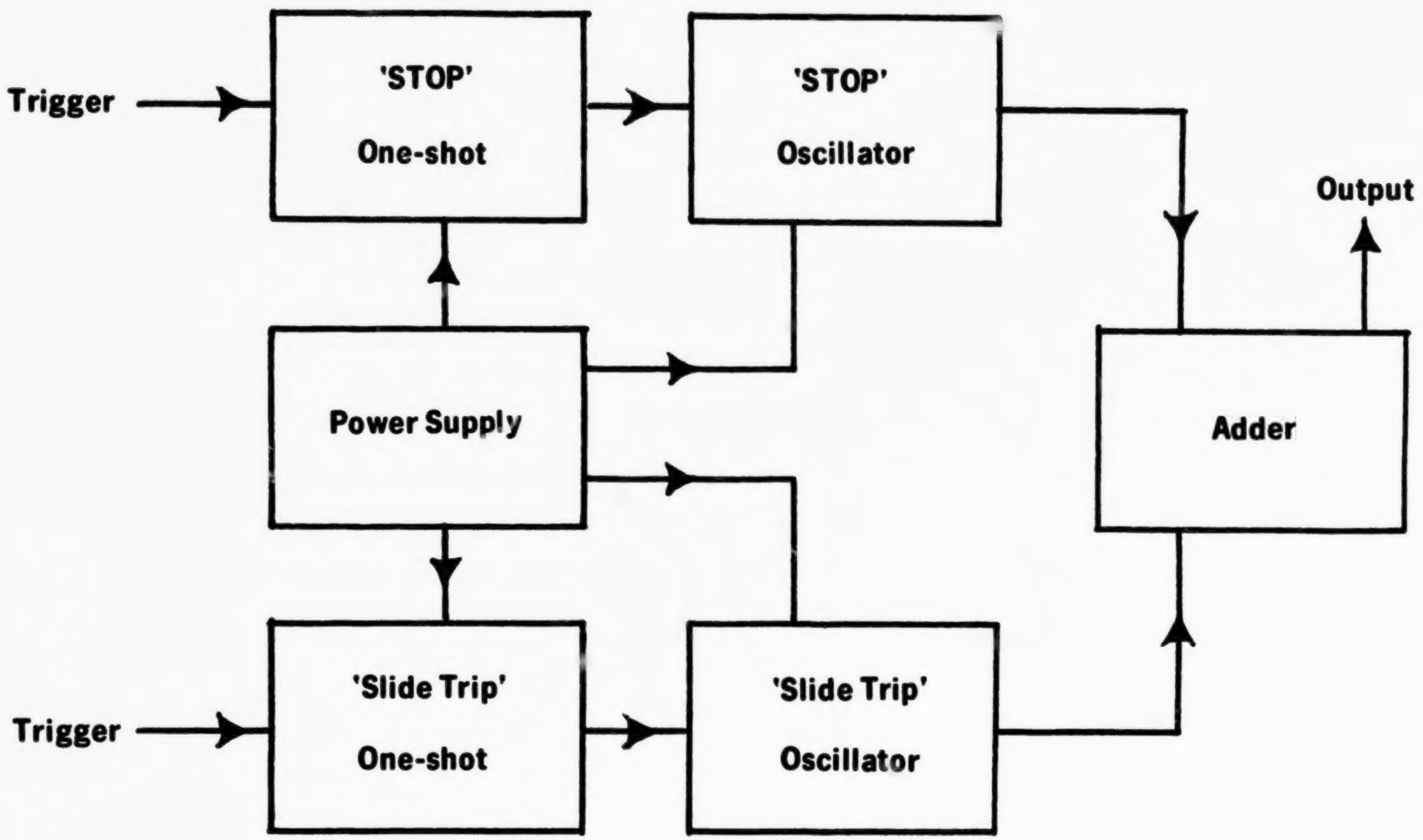


Figure A-4. BLOCK DIAGRAM OF THE TONE BURST GENERATOR near the center or outside of the spool.

B. The Control Signal Source

Control signals are nominally 200 Hz. for "stop" and 2000 Hz. for "slide trip." They are generated in a home built unit, the Tone Burst Generator, whose circuit is shown in Figure A-5. The two sinusoids are produced by separate phase-shift oscillators, which are only energized when the particular one-shot associated with each is operated. The control panel contains a power switch, a pilot lamp and two momentary contact switches, appropriately labeled. The switches are interlocked, so that the tones of both frequencies cannot be produced simultaneously, although this feature is not needed. The triggering method used results in a burst of about one-third second regardless of how long the button is depressed.

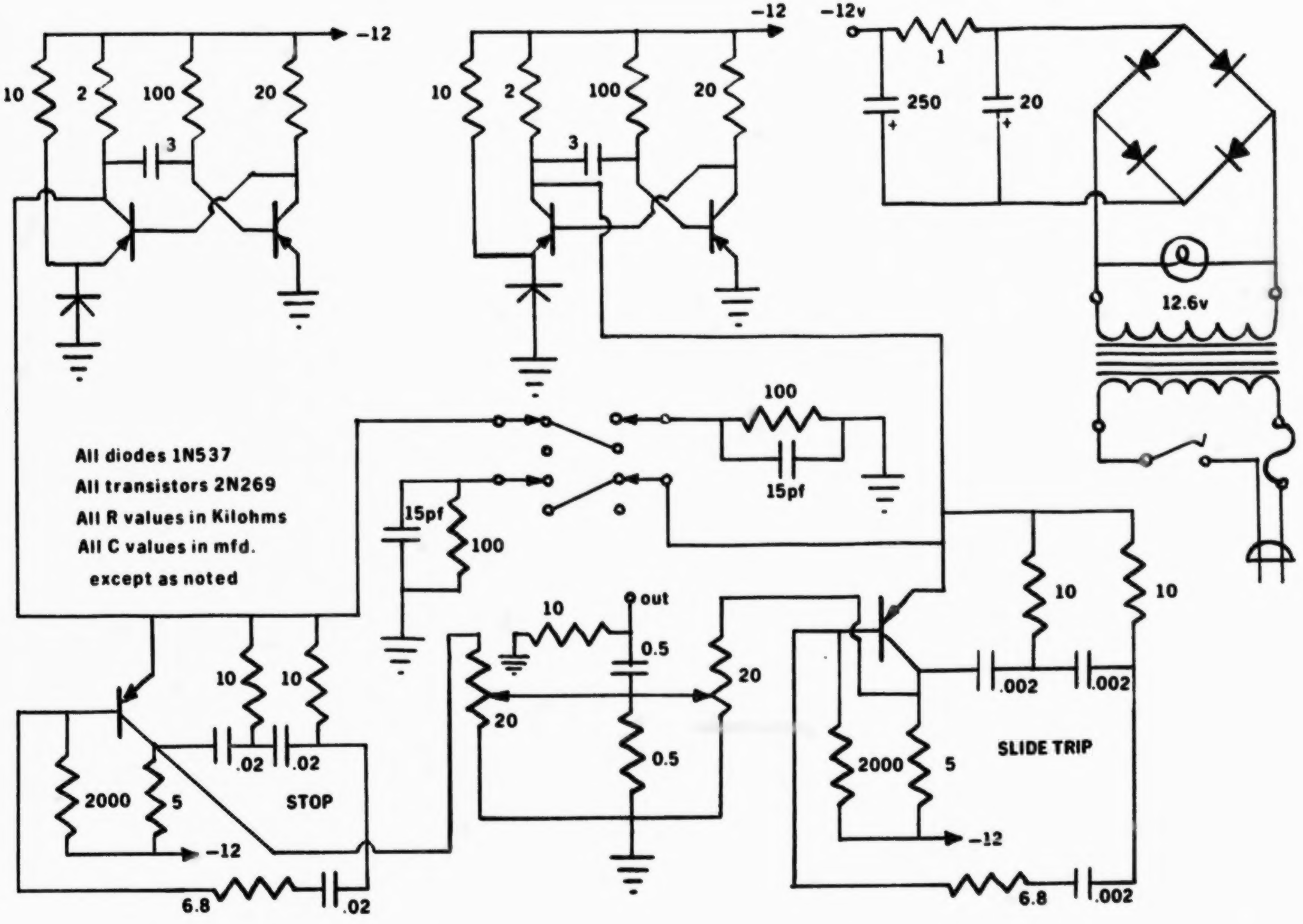
The unit has performed satisfactorily and is quite flexible, but if redesigned should probably use a multivibrator and integrator instead of phase shift oscillator, and possibly a single one-shot and single oscillator with the button determining the oscillator frequency.

C. The Tape Player

The tape players in use are of the four track stereo cartridge type. More specifically they are called "Tape-Dek II" and made by the Automatic Radio Mfg. Co. The units are modified slightly in order that the channel I output level cannot be changed by adjusting any front panel controls. The modification consists of clipping the lead to the center tap on the front panel "balance" control, removing the 4 clips connecting the panel mounted tone and volume controls to the printed circuit board, and soldering an attenuator to the connectors. The attenuator consists of a 3.9k resistor and a I k trimmer pot mounted so that it can be adjusted to be in just the right spot. The attenuator is usually set to clip the amplifier output slightly on slide-trip signals recorded at high level. It is expected that these units can be serviced by electronic equipment repairmen so long as a note explaining the modification is enclosed.

D. The Power Supply

Automatic Radio power supplies, model EPS



All diodes 1N537
All transistors 2N269
All R values in Kilohms
All C values in mfd.
except as noted

Figure A-5. TONE BURST GENERATOR CIRCUIT

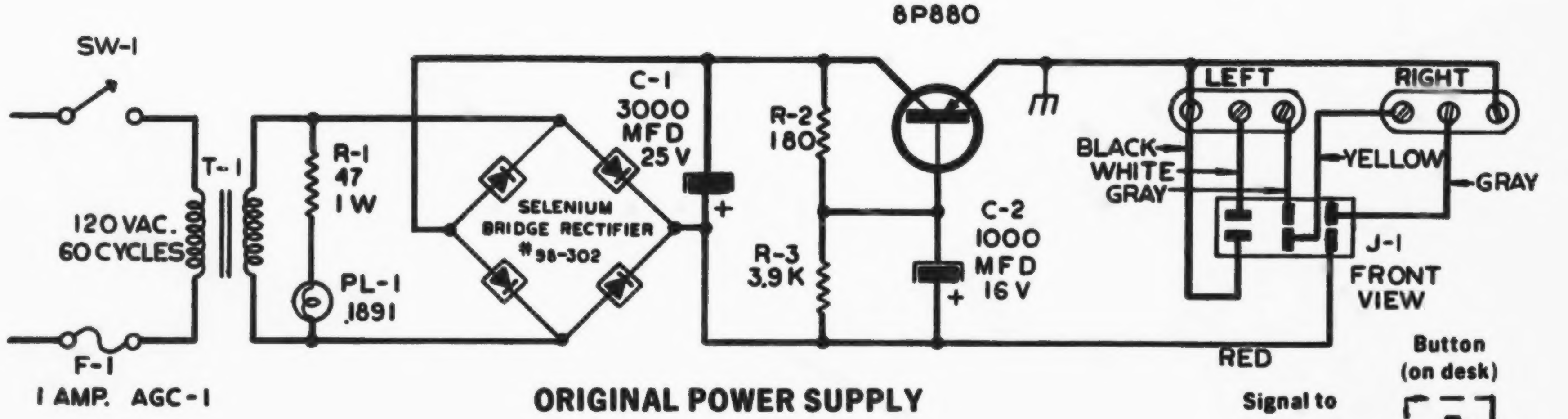
6363 are used as companion units to the tape players. They are supplied with a cable and plug which connects to the tape player, carrying the outputs of the tape player to terminals for loudspeakers located on the power supply. The reason for this arrangement is convenience. Normally the tape player operates in an automobile, but may be removed and used at home by plugging in the single cable connector.

In this application, the power supply was modified considerably. The physical changes consist of disconnecting the leads from the left side terminals (looking from the rear) in order that they may be used as the terminals leading to the switch which restarts the player after a "stop." The ground terminal on the left is also removed. The on-off switch is removed and a relay installed in the space thus left vacant. One side pannel also has several holes drilled to permit the control unit box to be fastened as an appendage to the power supply.

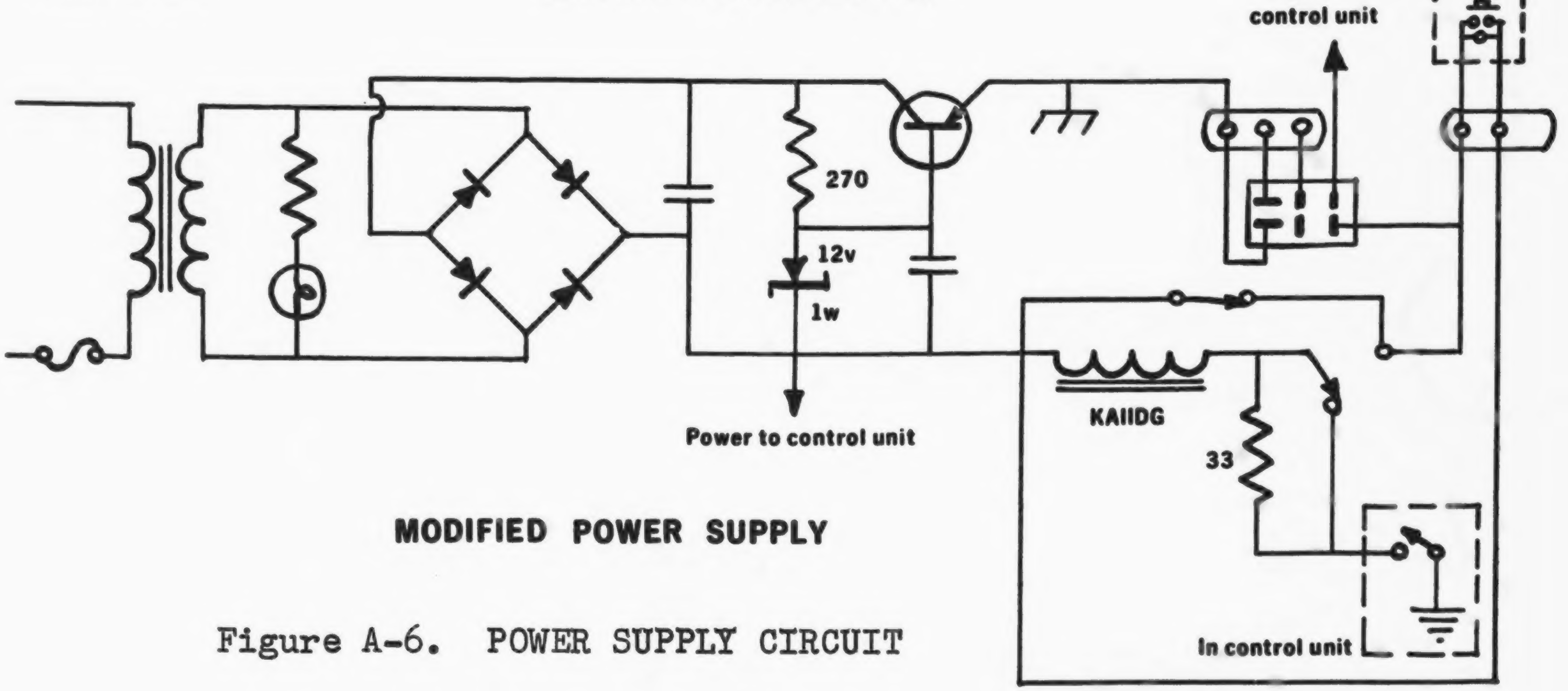
The power supply comes equipped with a single transistor which drops the voltage from 18 to 12 or 14. The output voltage with no load, however, is over 20. In the present application, there are times when the main load is disconnected, but unusually high voltage changes are not desired on the signal unit, so some regulation must be incorporated. An additional 100 ohms is added to the 180 ohms resister in the base circuit, and the 3.9K resistor is replaced by a 1 watt 12V zener diode. The actual circuit used is shown in Figure A-6. Notice the interesting circuit around SR 2, the second "stop" relay. When not energized, one of its normally closed contacts carries the load current. The "start" button is short circuited, and manipulating it cannot affect the circuit. When the contact of SR 1 operates momentarily, however, SR 2 is energized, and locks in its energized condition since the load current now flows through its coil. The 33 ohm resistor is needed to make SR 2 operate rather than buzz. Most of the supply voltage now appears across the coil (and the start button) and very little across the load. The start button is an illuminated bell button, and its glow is an indication of the "stop" condition. Pushing either "Stop" button shorts the relay coil, and its contact then closes, carrying the load current.

E. The Control Unit

The control unit is not commercially



ORIGINAL POWER SUPPLY



MODIFIED POWER SUPPLY

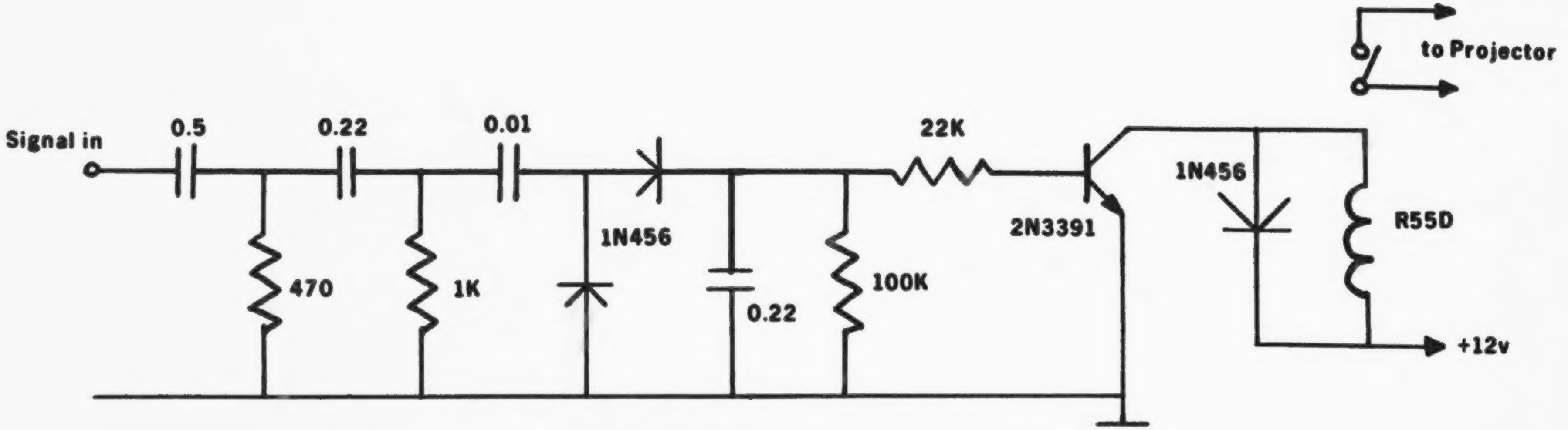
Figure A-6. POWER SUPPLY CIRCUIT

available. It is constructed on a piece of perforated fibreboard about 2 1/2" by 5" which is mounted in a 5 1/4" x 2 1/8" minibox which is in turn bolted to one side of the power supply unit. The electrical circuit is shown in Figure A-7. There are two RC filters, one low pass, and one high pass, with cut off frequencies around 750 Hz. They each drive "diode pump" circuits, the high pass, for "slide trip," with a capacitance ratio of 22, and the low pass, for "stop," with a capacitance ratio of 10. The slide trip relay closes a contact which is connected in place of the "slide advance button" on the slide projector, and the stop relay in the power supply box, previously discussed. An attempt has been made here to use the amplifiers in the tape player to the greatest extent possible, and to then use as few components as possible in the control unit. Note that there are no gain adjustments at all. The lower threshold, to eliminate noise, is provided by the use of silicon diodes and a silicon transistor. Short noise spikes do not have enough "cycles" to charge the diode pump output capacitances to a value sufficient to trigger the relays. This immunity to noise is very important for reliable operation. In actual use, slide trip signals do not trigger the slide trip relay unless they have been recorded at least at the level indicated by the "red" design in the usual recorder level monitor.

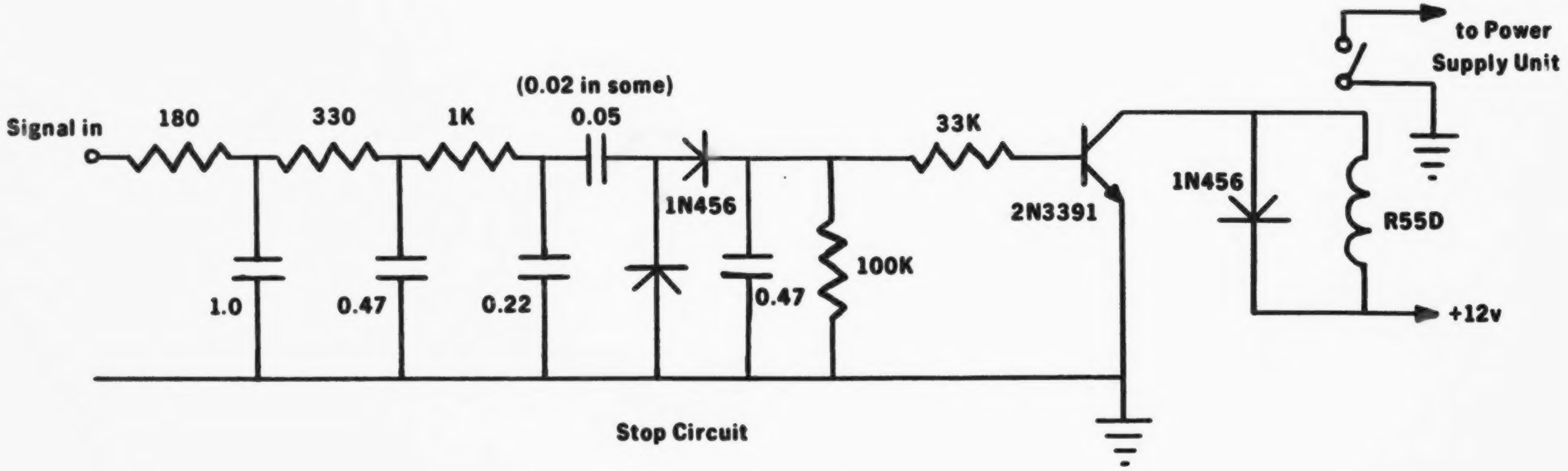
VI. Results and Recommendations

Several of the magnetic tape systems just described have been in daily use in the AVM Desks for nearly six months. The operating experience has been generally good, but there are a number of precautions to be observed to insure proper performance. It is essential that the control signals be recorded at a high level. It is anticipated that with time and use the signal output upon playback will be reduced, so a reasonable margin of excess signal should be provided on new tapes. No aging effects have been noticed, however.

A difficulty which did arise was due to the fact that auto tape players, unlike recorders, are not equipped with braking devices and when the power is interrupted, they gradually coast to a stop. When reenergized, some time is also needed to recharge the amplifier capacitors. The result is that after a stop signal the system is not responsive to anything recorded on the tape for about a second. If a



Slide Trip Circuit



Stop Circuit

Figure A-7. CONTROL UNIT CIRCUIT

"slide trip" signal is recorded following a "stop" signal (as is often the case), it is essential that the "slide trip" signal be delayed enough to avoid the dead time. The voice program should also have a pause of more than a second after every Stop."

There have been a few problems associated with the tape players, some due to poor components, and some to poor assembly, but the only serious problem has been delay in supplying factory replacement components.

The fact that tapes must be played through and cannot be rewound has not proved to be much of a problem for normal operation, but is certainly inconvenient for service procedures. It is very useful to make a special short test tape with control signals recorded at successively decreasing levels. The use of this tape quickly indicates any sensitivity variations of the players and associated equipment.

The slide projectors have caused little trouble but are potential sources of difficulty for two reasons. When the main switch is turned off at the end of each program, both the projection lamp and fan are de-energized. Kodak recommends that the fan be left running fro a few minutes to avoid the possibility of projection lamp glass softening and possible damage to a condenser lens. We have had no difficulty of this sort, probably because the projection lamps have been operated in their "low" switch position. The other problem is also related to projection lamp heat. Unless the projector is positioned in the enclosure in such a way that its fan blows the heated air out, the entire enclosure including projector, power supply, and player may become overheated.

An advantage of this system over those wherein a special recorder-playback unit is used has recently become apparent. It is now possible to produce any number of copies of properly prepared tape programs with a minimum of time and effort.

One possible addition to the system has been discussed but not yet implemented. As an aid to evaluating the responses of students using the Desk with no direct supervision, it should be easily possible to add a small secondary tape recorder and microphone. This would be energized only when the "stop" light was on. The tape length for each student would then be a measure of the total time he took in making response. The particular vocal responses requested during the program would be recorded on the tape for each student and could be subjected to a quick evaluation at the end of each day's use. Automatic or recorded evaluation of manipulative responses has been discussed and is possible, but not by such simple means.

APPENDIX B

TEACHERS MANUAL
FOR THE AVM INSTRUCTIONAL SYSTEM
ARITHMETIC FOR THE MENTALLY HANDICAPPED

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I. Introduction

A. Problem

As all teachers realize, when children begin the first grade of elementary school, certain assumptions or value judgments are made concerning the amount of previous concept development that the various children in a class may have gained. As an individual progresses from one year to the next, such suppositions by teachers are continuously made. However, just as normal children mature socially at different levels and speeds, children also develop their mental capacities at different rates of speed. This divergence is even more marked when it concerns mentally handicapped children.

Individual differences between all children exist, but the mentally handicapped children as a whole learn and progress in growth much more slowly than the average child. As a result, their individual variations are much more pronounced and erratic. Therefore, assumptions regarding the concepts such children may possess as they continue in school have a much greater chance of being unstable.

As a result of the learning variability found in the special classes for the educable mentally handicapped, the teacher realizes that her pupils have reached or failed to reach several different levels of concept development. Thus, she must spend a great percentage of her time working with her pupils in very small groups or even individually to help each develop at his own level.

Even though the number of pupils in a special class is reduced from that of the average class, it still remains especially difficult for the teacher to have enough time to help each of her pupils individually. One area where help may be found for teachers in their attempts to deal with individual differences is programmed instruction. To have programmed materials available to identify whether children know certain concepts and to have programmed materials available to help teach handicapped children the concepts they lack, should be an asset to a great many pupils.

With this background in mind, an audio-visual-manipulative desk, programs designed to teach basic arithmetic concepts, and the materials to accompany the programs were developed in the office of Research and Psychological Services, Giffen Memorial School, Albany, New York, through a grant from the Branch of Handicapped Children and Youth, of the United States Office of Education (Demonstration Proposal 32-42-6165-5005).

B. Purpose

The purpose of the programs designed for use in the Audio-Visual-Manipulative Desk (AVM Desk) is to teach basic arithmetic concepts. The purpose of using the programs and the AVM Desk is to aid the teacher in her task of reaching all of her pupils--individually, on their own conceptual level. The instructional materials serve this "aiding" purpose in at least four different ways.

First, it enables the teacher to make better use of her time in that she can be working with another child or a group while one child is going through the program.

Second, the teacher may use the Pre Post Test to determine readiness. There is a Pre Post Test with each of the three units of programs. The Pre Test is given before the child experiences any of the teaching programs. The results of the test will help the teacher judge whether or not the child already understands the materials of each particular unit.

Third, the programs may be used on a remedial basis, only, to help each individual child with his weak points.

Last, the activities or accompanying materials are considered. For each program produced, instructional materials have been developed which are appropriate for the teacher to use with individuals and groups. The purpose of these materials is to reinforce the learning and thereby to improve retention. Most of the activities are in game form and they make use of manipulative materials such as magnetic and flannel boards and figures. These activities may be used after all the children in a class have experienced the AVM Desk and programs in order to help determine or aid learning, or in conjunction with programmed instruction or may be used independently of the AVM Desk instruction.

The materials available to date are designed to teach selected arithmetic concepts to educable mentally handicapped pupils whose mental ages are between 60 and 96 months and whose IQ's are between 50 and 75.

C. Early Findings

Four separate field studies, pilot studies, have been conducted for the purpose of evaluating the programmed materials in arithmetic. The first study was designed to determine the relative effectiveness of the programmed materials versus conventional instruction. Two classes of EMH pupils were exposed to these concepts through programmed instruction and two other classes were taught by the teachers of the classes. All classes improved. However, the mean Post Test scores of those classes taught by programmed instruction were considerably better than the mean Post Test scores of those classes taught by conventional methods.

The second study was designed to compare the learning and retention of those children exposed to the programmed materials once with those exposed two times. Twenty eight pairs of children matched on sex and mental age, drawn from a pool of 75 EMH children located in five special classes, in one school, were differentially exposed to the programmed materials. The mean gains, Pre Post, were significantly different. The group exposed twice gained more than the group exposed once. However, on the follow up, a month later, the differences were not significant.

In both of the first two studies, the programmed instruction was under the supervision of a research assistant. The third study was designed to determine whether the programmed instruction could be used effectively by teachers. Thus, the AVM system was placed in four different classrooms; only the Pre and Post tests were administered by a research assistant. The results indicated that the teachers could utilize these materials effectively; the children did improve in knowledge and understanding of arithmetic concepts and skills; the children enjoyed using the desks; the teachers wanted to continue to use the materials. Teachers found that the AVM Desk was easily integrated into the routine class procedures.

The fourth study indicated that few trainable EMH children profit from one exposure to Unit I.

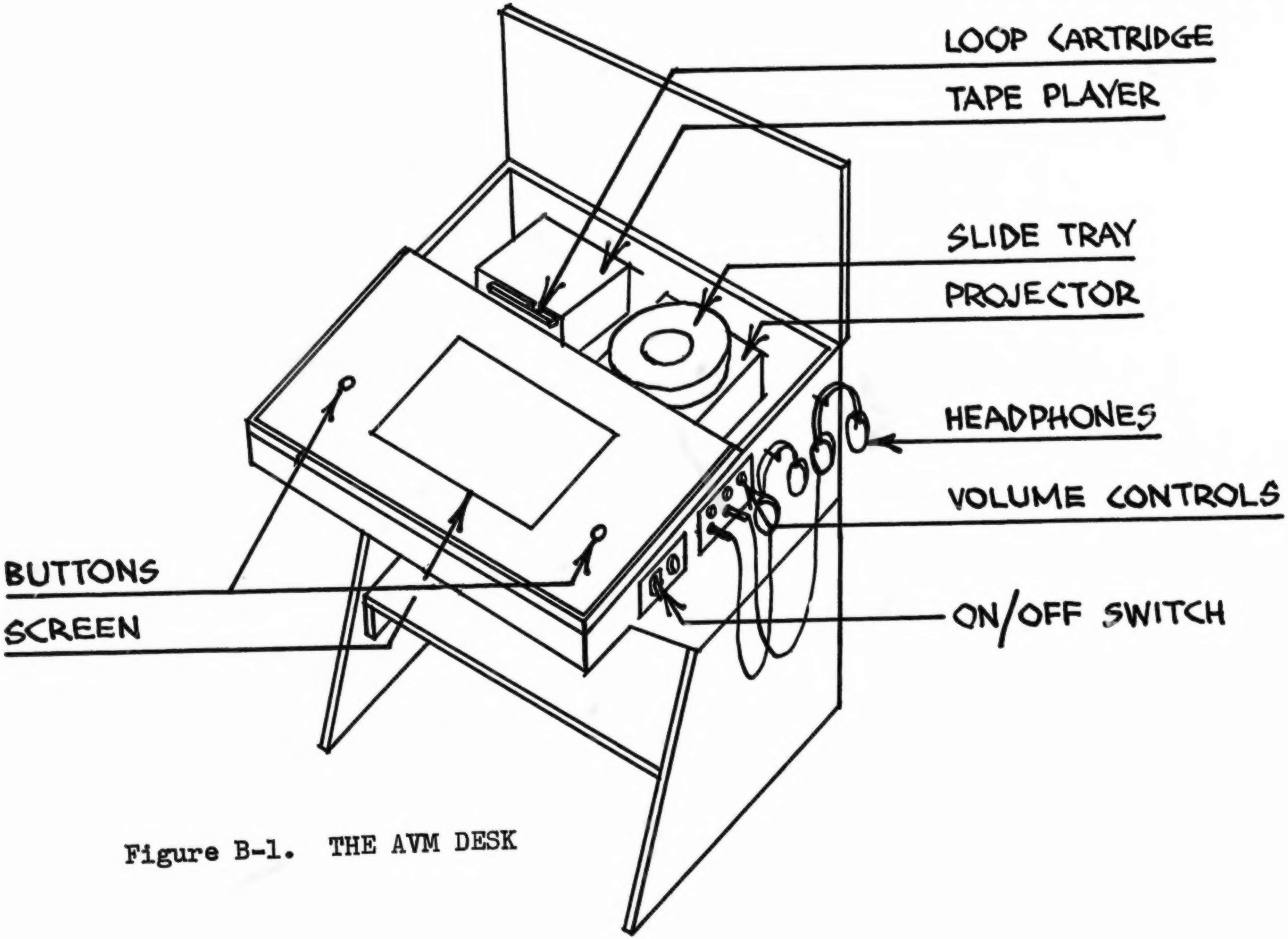


Figure B-1. THE AVM DESK

II. Instructional System

The instructional system consists of the AVM Desk and the instructional materials.

A. Description and Use of the Desk

The Audio Visual Manipulative Desk is used to present the arithmetic programs to the children. Inside the desk are a cartridge tape player, a power supply unit and a slide projector. This equipment within the desk is used simultaneously to present the programs to the child. The child hears the program through earphones while corresponding slides are being projected on the screen. Both verbal and motor responses are required. The machine is paced so that the child may have as long as he wants to make a motor response but only a certain amount of time to make a verbal response; that is, motor responses are pupil-paced, and verbal responses are machine-paced. When the child is asked to make a motor response, the tape trips a stop signal so that the program will stop temporarily in order for the child to make his response. When he is finished, the pupil presses a lighted button on the surface of the desk, and the program continues.

During the programs the child is presented with many devices or artifacts that he can manipulate. Such manipulation helps the child to use and to combine the use of many of his senses, such as sight, hearing and touch. In this manner, the child is given practice in improving his visual motor co-ordination. To put it another way, co-ordination between doing and thinking is encouraged and reinforced.

There are several steps that must be followed in order to set the machine up for proper use. They are as follows:

1. The desk lead is inserted in the wall socket. The desk is turned on by pushing up on the switch at the side of the desk.

2. The carousel slide tray must be inserted into the holder in the projector. It is placed at zero where the notches of the tray and projector fit together.

3. All the programs begin with slide number 1 so the slide tray must be moved to that position. This is done by pressing and holding the "select" button down with one hand and moving the tray counterclockwise to the position for slide number one. At this point the projector is ready and the switch at the side of the desk should be turned off so that the loop cartridge may be inserted.

4. To load the tape player, take an endless loop tape cartridge and hold it far to the right of the tape player opening, then press the cartridge firmly in place. The AVM Desk is now ready to present a program.

5. Place artifacts, water soluble ink pen and moistened sponge on the desk.

6. The child must be instructed to put on the earphones. The volume of the earphones may be controlled by changing the position of the appropriate knob on the side of the desk. He may use the pen (water soluble marker), sponge (to erase the screen), and artifacts as the program asks him to do so. It must also be explained to him to press either of the glowing buttons when he is finished with a particular task so the program may continue.

7. When the child is seated at the Desk, the switch on the side of the Desk is turned on. The child proceeds through the program by following the directions recorded on the tape.

B. Instructional Materials

1. Unit I Program 1 Sets.

a. Objectives. The purpose of this first program is to introduce to the child the concept of "set." The idea of set is perhaps the most significant concept which threads itself throughout all of mathematics. Each new mathematical idea which the children will meet relates to set concepts. Therefore, to thoroughly teach this concept to the child is the first objective. The commutative and associative properties are not stressed as such in the program.

In the program, the child first learns to specify verbally that a group or collection of objects is a "set." He also learns to identify a set by pointing to a collection of objects within a circle. Another means by which the child comes to understand the concept of "set" is by motor specification of a set by (1) drawing a circle around objects and (2) placing objects within a circle.

The developmental sequence for grouping or placing objects within a set is as follows: (1) grouping of identical objects, (2) grouping of elements with some common characteristic, i.e., color, size, shape, function, (3) grouping of objects at random. In this first program the child groups only identical objects in sets.

In conclusion, the child learns two things: (1) to name a group of objects as a "set," and (2) to form a set of specified objects.

b. The criterion behavior is as follows: (1) Verbal specification of a group of objects as a "set;" (2) Identification of set as a collection of objects within a circle by pointing; (3) Verbal identification of a collection of objects within a single circle as a set of objects; (4) Motor specification of set by drawing a circle around objects; (5) Motor specification of set by placing objects within a circle.

c. New Vocabulary: Group, set, ring.

d. The AVM Program Inventory is as follows: (1) Slides and Frames: 46 slides, 27 teaching frames, seven cue frames; (2) Responses: 11 motor, 16 verbal; (3) Manipulative Materials: three knives, two spoons, four forks; (4) Time: 12 minutes.

e. The classroom activities include:

(1) Flannel Board

Materials: Flannel board, flannel board cutouts: large oval ring, four each of stars, discs, birds, apples.

Activity: Scatter the cutouts on board, some inside of ring, and some outside of ring. Teacher and/or pupil requests of child, "Make a set of all the stars." Child makes set and identifies the set. Then child scatters the cutouts. Continue with other cutouts.

(2) Game: The Set Makers

Materials: 8" x 10" acetate cards with string loops. Four each of stars, discs, birds, and apples.

Activity: A chalk circle is drawn on floor. Pupils are randomly assigned to two teams. Each team selects a captain. The captains distribute cards which are suspended across the shoulders. Captain A selects a member of Team B and requests, "Make a set of all the horses." The member of Team B finds all the horses in Team B and leads them into the circle. Children in the set chant, "We are a set of horses." Each child then returns to his team. Alternate with A and B teams. Record score of each team. Acetate cards may be redistributed among children.

(3) Supplementary Activities

The teacher places several boys within chalk ring on floor. This demonstrates a set of boys. Same for girls; same for boys and girls, which demonstrates a set of children. A child selects several classmates. Another child draws chalk circle to demonstrate that children now are a set.

Pupil chooses classmates and places them in circle and explains, "John and Mary are in the set," or "This is a set of boys and girls" or "This is a set of children." The Farmer in the Dell may be modified by identifying the children in the set, as the game progresses.

Teacher and pupils may refer to any group in the room as a set, e.g., Row 1 is Set 1, etc.

2. Unit I Program 2 Elements of a Set

a. Objectives. Once a child has learned the concept of set, he is ready to learn about the individual members of a set. The term used to identify the objects in a set is "elements" of a set.

Objects are usually grouped together as a set for some specified basis or purpose. That is to say, there is a property which each object or element has that determines it as a member of a

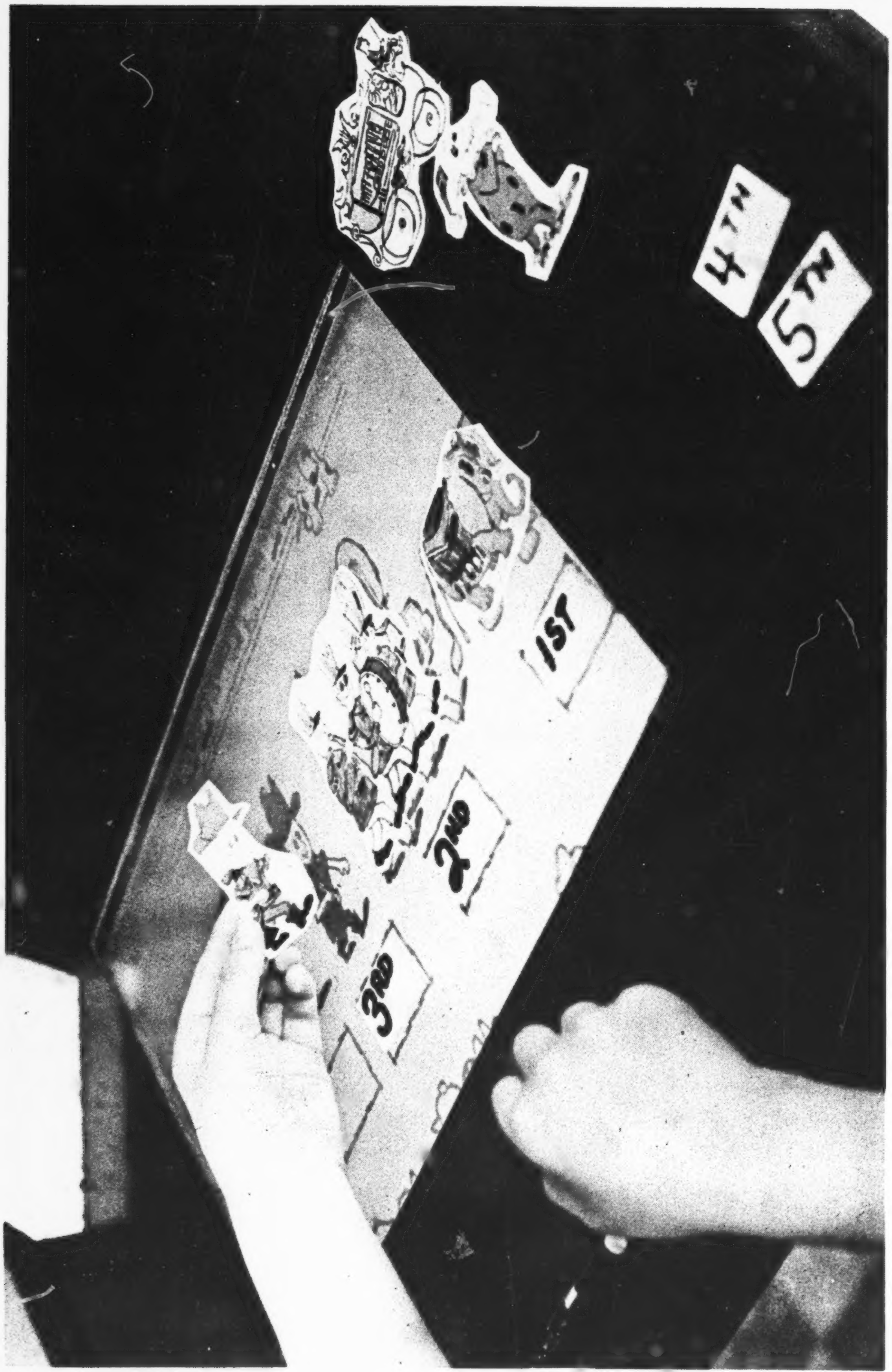


Figure B-2. MANIPULATING OBJECTS AT THE AVM DESK specific set. An element may belong to a set merely because we list it as a member of the set, or because it satisfies a rule which assigns elements to the given set.

As in all the programs, the child learns to identify an "element" by both verbal and motor means. The child verbally identifies objects within a set as "elements of the set," as well as naming specific objects within a set as elements. The negative approach is also used in that the child is asked to specify that objects outside of a circle are "not elements of a set." The motor identification of elements of a set is presented in three ways, (1) identification of an element by writing an x over an object, (2) specification of an element by placement of an object within a circle and (3) specification of a set by drawing a line around verbally identified elements in a field of objects.

b. The criterion behavior is as follows: (1) Objects within a set verbally identified as "elements of the set;" (2) Motor identification of element by writing an X over an object; (3) Verbal specification of elements within a set by naming the elements; (4) Verbal specification of sets as made up of elements; (5) Verbal specification of objects outside a circle as "not" elements of the set (negative instance;) (6) Motor specification of element by placement of objects within a circle; (7) Motor specification of set by drawing a line around verbally identified objects in a field of objects.

c. New Vocabulary: Element, elements of a set.

d. The AVM Program Inventory is as follows: (1) Slides and Frames: 47 slides, 121 teaching frames, 9 cue frames; (2) Responses: 9 motor, 112 verbal; (3) Manipulative Materials: 1 knife, 1 spoon, 1 fork, 1 hammer; (4) Time: 25 minutes; (5) Special Instructions: The tape of this program has been packaged in two cartridges. For those children who are unable to complete the program in a single sitting, the presentation may be in two parts. Note: Be sure carousel tray is at Slide 21 when presenting Part B.

e. The classroom activities include:

(1) Game: Tika and Coco

Materials: 20" x 30" chart (No. 1) Palm Tree, magnets and two monkeys. Ten 8" x 10" acetate cards as follows:

Card No.	Objects in Set	Objects not in Set
Sample	Watermelon and apple	Frog
1.	Bowl, lamp, mug, telephone, radio	Television
2.	Fish, worm, fishing rod	Boy in rowboat
3.	Comb, dress, kite building	Mailman
4.	Frog, dog, turtle, goat, fish	Bottle cap
5.	Rocket, bottle cap, red, white, and blue flag	Green and white flag
6.	Dog, cat, tree, car	Telephone pole
7.	Lamp, table, desk	Sofa
8.	Apple, orange, banana	Watermelon
9.	Mailman, doctor, policeman	Fireman
10.	Three monkeys	Fish

Game directions: Teacher says, "Today, boys and girls, we are going to play with Coco, the little boy monkey, and Tika, the little girl monkey. The girls will use Tika and the boys will use Coco. You can help your team's monkey to reach the top of the palm tree by answering some questions. I am going to show you a picture of some objects. See if you can name the objects which are elements of a set. Let's look at the first picture together. Which objects are elements of the set?"

Response:

"The apple and the watermelon are elements of the set." (No credit is given for just saying: "The apple and the watermelon." The answer must be in a complete sentence).

Teacher:

"When a right answer is given, your team's monkey moves up one step. If an object is named which is not an element of the set, that team's monkey is moved back one step. The first monkey to reach the top of the tree shows which team has won."

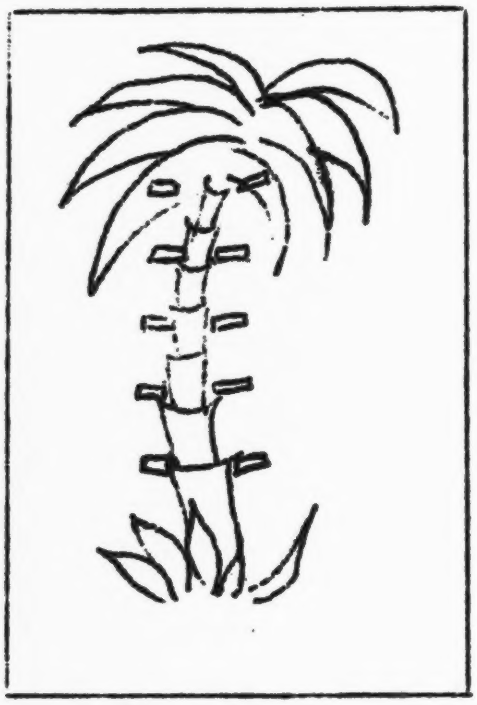


Chart No. 1

3. Unit I Program 3 One-To-One-Matching

a. Objectives. This program is designed to help the child develop an understanding of equivalence. Two sets are in one-to-one correspondence if there is a pairing of the elements of these sets such that each element in each set is matched with exactly one element in the other set. It is not important for the kinds of elements to be the same. It is the number concept which is of value for the child.

The child learns to match the elements of a set by (1) drawing lines from individual members of one set to individual members of another set, (2) verbal identification of sets whose elements match one-to-one, and (3) verbal identification of sets whose elements do not match one-to-one.

The idea is to teach the child to recognize that two sets of different elements can still have the same number. The long range desire is that the child will learn to understand that the number concept can exist for an object separate from all the other properties of that object.

b. The criterion behavior is as follows: (1) Motor matching of elements of a set by connecting or drawing lines from individual members of one set to individual members of another set; (2) Verbal identification of sets whose elements match one-to-one; (3)

Verbal identification of sets whose elements do not match one-to-one.

c. New Vocabulary: Match one-to-one, do not match.

d. The AVM Program Inventory is as follows: (1) Slides and Frames: 68 slides, 45 teaching frames, 13 cue frames; (2) Responses: 12 motor, 33 verbal; (3) Manipulative Materials: three yellow soldiers, three spoons, three forks; (4) Time: 15 minutes.

e. The classroom activities include:

(1) The Squirrel Family

Materials: 20" x 30" chart (No. 2), six little squirrels.

Instructions: Teacher says, "Mrs. Squirrel has six little squirrels. Each squirrel lives in a tree of his own. The baby squirrels play all day. When it gets dark, Mrs. Squirrel always worries if any baby is lost in the woods. Mrs. Squirrel does not know how to count. Let us help Mrs. Squirrel find all her babies."

Give six squirrels to six children. Request, "Put the squirrels in the trees. If there is a squirrel in every tree, the baby squirrels and the trees match (how?)"

Chart No. 2

Have six other children take the babies out to play. One child hides his squirrel. Request, "Put the squirrels in the tree. Is there a squirrel in every tree?"

"No, one squirrel is lost. The baby squirrels and the trees do not match (how?)"

Continue activity with different children and different number of squirrels in the trees. Under each condition, have children explain, "The baby squirrels and the trees do or do not match one-to-one."

(2) Game: Do They Match?

Materials: Flannel board; two large size flannel rings; flannel cutouts of orange, apple, banana, hammer, frog, saw, cat, dog, radio, camera, boat, fish, bottle, ball, bat, glove; three flannel strips 1/2" x 9"; three flannel strips 1/2" x 12"; three flannel strips 1/2" x 15".

Instructions: Randomly assign children to two teams. Give each team captain an assortment of flannel strips. Give each team member a flannel cutout. The teacher asks members of Team A to place certain cutouts in Set A, same for members of Team B. Teacher says, "Captain A, use your flannel strips and see how the elements of Sets A and B match."

After Captain A places the strips, he asks a member of his team to state how the elements match.

Alternate procedure with Teams A and B, varying conditions of matching one-to-one and not matching one-to-one.

Team with most successes wins.

(3) Game: Three Bears

Materials: Flannel board and flannel cutouts of Papa, Mama, and Baby Bear, large, middle-size and small dishes, chairs, beds, and jackets. Flannel rings are not used.

Instructions: Randomly assign children to three teams. Distribute the Papa cutouts to Papa team, same for Mama and Baby teams. Place Papa, Mama and Baby Bear cutout on three sections of the board.

The teacher selects the members of each team to place their cutouts on the board.

All combinations of cutouts are distributed so that the elements of the three sets match or do not match, e.g., in selection of members, initially have all elements placed in each set. Each team declares, "The sets match one-to-one." Later, not all elements are placed in each set. Each team declares, "The sets do not match one-to-one." Two sets may match one-to-one but third set may not match.

On each trial, after cutouts are placed on flannel board, a particular team confers, then in unison declares, "The elements of the sets do or do not match one-to-one." As skills are developed, the teams signify why elements do or do not match one-to-one, e.g., "There is a dish for every bear." As skills are developed, each team in turn confers and distributes the cutouts.

The number of correct games determines the winning team.

(4) Crayon Man

Materials: 15 crayons

Instruction: Select four children. The team selects the crayon man. As he distributes four crayons, the class recites:

"Crayons, crayons, oh what fun!
We will match them one-to-one.
One for Jane, one for Bill,
One for Bea, and one for me!"
(the crayon man).

As Crayon Man distributes three crayons, the class recites:

"Crayons crayons, oh what fun!
Do we match them one-to-one?
One for Jane, one for Bill,
One for Bea but none for me!"

(5) Supplemental activities. Introduction to matching may be effected by having children raise fingers to match the number of taps made by the teacher.

Reading: Clark, Margery. The Poppy Seed Cakes, Doubleday Doran Co., Inc., 1924.

Dagliesh, Alice, "The Hot Day," The Hollyberrys. Scribners Sons, 1939.

Song: Where is Thumbkin? Kindergarten Book, Ginn and Company.

4. Unit I Program 4 Pre Post Test

a. The AVM Program inventory includes: (1) Slides and Frames: 20 slides, **nine** cue frames, 21 criterion frames; (2) Responses: **seven** motor, 14 verbal; (3) Manipulative Materials: One each of a spoon, pear, and red block, two toy cars, three apples, two cherries; (4) Time: ten minutes.

5. Unit II Program 1 One

a. Objectives. The objective of many of the programs in this unit is to teach the meaning of certain numbers. We start, naturally, with the numeral "1." The attempt is made to progress from the child's understanding of sets and elements to the new concept of number and the idea of numerals. The development begins with introducing in the program a set which has one element. The child is given practice in recognizing sets of one element by (1) pointing to the set with one element and (2) naming or identifying the one element in a set. He is then asked to give the response "One" in answer to the question, "How many elements are in this set?" At this point, the child learns to abstract all the other properties from an object in a set and he thinks only in terms of number.

The objective of this program is to help the child understand that a number can be represented as a specific numeral. He is taught to recognize the numeral 1 and to relate his recognition by (1) placing the numeral 1 on top of a set with one element and (2) by writing the numeral 1 in the placeholder below a set with one element.

In summary, the program teaches the concept of number one and the representation of this concept by the formation of the numeral 1.

b. The criterion behavior is as follows: (1) Motor identification (pointing) of set with one element; (2) Verbal identification of one element in set of one by naming element; (3) Verbal response one to question "How Many?" in context of single object, set of one element, one specified object in group of several other objects; (4) Motor identification of set of one element by placement of numeral 1; (5) Identification of one element set by writing numeral one in placeholder.

c. New Vocabulary: One, numeral.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 60 slides, 38 teaching frames, six cue frames; (2) Responses: 14 motor, 24 verbal; (3) Manipulative Materials: Two blocks, the numeral 1; (4) Time: 12 minutes.

e. The classroom activities include:

(1) Flannel Board

Materials: Flannel cutouts, one 6" numeral 1, single chick, bunny, duck, and bird, four oval rings.

Instructions: Place numeral 1 in center of board. Place four oval rings on board. Distribute single cutouts to four pupils. As the class recites:

"One little chick went peep,
peep
One little bunny went to sleep.
One little duck went quack,
quack,
As one little bird fell asleep
on his back,"

the children place cutouts within single ovals which make individual sets.

As the cutouts are removed, each child announces, "I will take one little chick, etc."

(2) Supplementary Activities. To reinforce motor identification of one object, as a group,

the children point to their one head, one mouth, one chin, one nose. Optional verse to be recited as the children point to the parts of their body:

"I have only one head,
I have only one mouth,
I have only one chin and one
nose,
But I find I have no trouble
at all,
I get along fine with those."

"How many sets of one can we find in the room?" Each child in turn responds, e.g., "I see one clock, etc." "I see one door." "I see one teacher." "I see one wastebasket." "I see one teacher's desk." "I see one record player." "I see one sink."

6. Unit II Program 2 Two

a. Objectives. In this program, the child learns the concept of the number two and recognition of the numeral "2" in much the same manner as he learned about "one" in the previous program. In addition, the child first experiences the natural order of whole numbers when he builds a set of two by adding "one more" to a set that already contains one element. The two motor behaviors he performs in learning how to make a set of two elements are: (1) adding one object to a set that already has one object ("one more" pattern), and (2) placing two objects into an empty set that is designated by an empty oval-shaped ring.

As in the previous program, the ability to identify a set that contains two elements by verbally answering the question, "How many elements are in this set?" shows the child can recognize and identify when a set has two elements.

The child also learns to discriminate a set of two elements from a set of one or three elements in several different manners by (1) pointing to the set with two elements, (2) placing a numeral 2 in the appropriate position, and (3) writing the desired numeral in the placeholder.

As in all of the programs, the child learns to express himself in two fashions, by verbal and motor means.

b. The criterion behavior is as follows: (1) Make set of two elements; (2) Discriminate set of two elements from sets of one and three elements by pointing, placing and writing numeral; (3) Identification of set of two elements by saying "two;" (4) Completion of sentence, "If you know the number, you know (how many?)" (5) Discrimination of sets as having the same or different number.

c. New Vocabulary: Same number, different number, how many.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 61 slides, 29 teaching frames, 14 cue frames; (2) Responses: six motor, 23 verbal; (3) Manipulative Materials: Two each of trees, flowers, birds; a single house. (4) Time: 20 minutes.

e. The classroom activities include:

(1) Game of Two

Materials: Fifteen 9" x 11" Game of Two sheets, each sheet consisting of nine cells which depict one, two or three animals under column headings T, W, and O; 99 (2 3/4" x 2 3/4") animal cards consisting of ten different animals in groups of one, two, or three and labeled T, W, or O; a cage (6" x 6" x 6") from which zoo cards are drawn; zoo inventory sheets; and 90 markers labeled 2 and 90 plain markers.

Directions: The class is divided into teams. Teacher or child acts as a zoo keeper, shuffling the TWO sheets and placing them face down on the table. Each player is allowed to draw a sheet. The markers are divided evenly among the players. The "2" markers will be used to cover pictures of two animals; the plain markers will cover all other pictures.

The zoo keeper selects an animal card at random from the cage, records the card on the zoo inventory sheet and announces that he has a T, W, or O card with one, two, or three butterflies, cats, etc. For example, the zoo keeper calls, "I have a T card with two butterflies." The player having a TWO sheet with this combination, then covers the two butterflies with a "2" marker.

The game proceeds with the zoo keeper calling the animals and the players covering their TWO sheets with appropriate markers until a player has three 2 markers in a row; then he calls "TWO " and the game ends. The player may have markers in a row, horizontally, vertically, or diagonally. On each sheet, there are two possible ways of winning. After the player calls "Two," he reads back the animals in his row and they are checked by the zoo keeper who notes if they are on his zoo inventory sheet. The number of games won by a team determines the winner.

(2) Supplementary Activity: Class recitation of the lines:

"I have two eyes with which to see
Two falling leaves from autumn's trees,
I have two ears with which to hear
Sound of thunder through the year.
I have two legs that jump and run,
As I have fun in summer's sun.
I have two hands with which to throw
Balls of snow at the buffalo."

During recitation, pupils point to the parts of the body. In response to the second line, the children may move their hands downward in a fluttering motion.

7. Unit II Program 3 One Plus One

a. Objectives. In programmed learning, the child acquires knowledge in very small steps. The material or subject matter being taught is broken down into bits of information which are ordered and arranged in a particular sequence of increasing difficulty. The information is presented to the child so that he may progress steadily from one part of the program to the next. The attempt is made to proceed from one program to another in much the same manner by gradual continuation of the smooth approach with small steps of growing difficulty. This background information is part of the explanation for teaching only the phrase

"1 + 1 = 2." The joining of sets themselves, which lays the foundations for the operation of addition, is introduced before the results of the union are completely understood. The object is to get the child to think and to be familiar with the concept of "one more," addition, and the plus sign, before he learns the result of such concepts, (i. e., the meaning of the equal sign, =).

The child is first taught to join two sets of one element each. The motor behavior of picking up one object and adding it to another set of one object helps him become aware of placing "one more" element in the set. At this point the plus sign (+) is introduced, and the pupil is asked to recognize this symbol by (1) pointing to the plus sign, when it is one of many other symbols in the picture, and (2) placing the plus sign between two elements or numbers to show that we want to add one more. The final step in teaching 1 + 1 is to have the child respond to the picture phrase 1 + 1 by saying "One plus one."

b. The criterion behavior is as follows: (1) Discrimination of plus sign by pointing; (2) Read the phrase 1 + 1.

c. New Vocabulary: Plus sign, +, plus, added.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 65 slides, 32 teaching frames, 6 cue frames; (2) Responses: 21 motor, 35 verbal; (3) Manipulative Materials: One each of tree, dog, bird, fish, numeral 2, two of numeral 1, plus signs; (4) Time: 15 minutes.

e. The classroom activities include:

(1) Plus Game

Materials: Six 5" x 8" cards of the numeral 1, four 4" x 5" cards of plus symbol, six 8" x 10" cards each of cow, horse, dog, cat, pig, duck.

Instructions: Divide the class into two teams. Give each team three animal cards, three cards of the numeral 1, and two cards of the plus symbol. Team A requests of Team B, "Show us one (dog) plus one (cow)." Members of Team B place cards in correct sequence on rail of blackboard, e.g., dog card, plus card, cow card, and announce, "One (dog) plus one (cow)." Team A requests, "Use the numeral cards and symbol card. Show the phrase, One plus one." Members of B team place cards in correct sequence, on rail of blackboard and announce, "One plus one." B team retrieves the cards. Teacher records time required. Alternate activity with Team A and B. Team with shortest time on three trials wins.

(2) Supplementary activity. Class in unison chants:

"This lion was a set of one.
(Child walks to front of room.)
But by himself he had no fun.
A tiger walked into his set,
(Another child joins first child.)
So now the set is one plus one."

(The class repeats:)
"So now the set is one plus one."

Children return to seats. Other animals and children's names may be substituted for lion and tiger.

8. Unit II Program 4 $1 + 1 = 2$

a. Objectives. The first complete equation or mathematical sentence that the child learns is $1 + 1 = 2$. In a child's learning and familiarization with this simple equation, he is really becoming familiar with three important concepts, (1) the idea of union or joining of two sets, (2) the idea of addition--(as also shown in program 3) and (3) the written form of the mathematical sentence.

The child first learns to identify a set of two elements by two different mathematical phrases. He does this by pointing to either "$1 + 1$" or "2" when either is presented in a group of several different numbers. The next step is for the child to complete blanks in the equation by placing the equal sign and/or the numeral 2 in the appropriate position of the number sentence. The last request of this program is for the child to read aloud the number sentence $1 + 1 = 2$.

At the end of this program, one assumes that the child has become familiar with the plus sign and the equal sign which are the foundations for building of addition mathematical equations.

b. The criterion behavior is as follows: (1) Number attribute of set of two elements noted as 1 + 1 or as 2 by pointing; (2) Completion of number sentence 1 + 1 ☐ 2 by placement of equal sign; (3) Read number sentence 1 + 1 = 2.

c. New Vocabulary: equal sign, number sentence.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 55 slides, 32 teaching frames, six cue frames; (2) Responses: 18 motor, 14 verbal; (3) Manipulative Materials: One each of equal sign, 2, 1 + 1, + sign; (4) Time: 12 minutes.

e. The classroom activities include:

(1) Fred Frog the Lifeguard

Materials: 20" x 30" chart (No. 3); four each of sea shells, soda bottles, life preservers, fish, beach balls, sailboats, bathers; one equal card, plus card, Lost and Found Box.

Instructions: Scatter certain of the objects about the room. Children select a member to be Fred. The child places the chart and stands by the chart.

Teacher: "Fred Frog, the lifeguard, works on the beach. He likes the boys and girls. He teaches them how to swim. He likes to keep the beach very clean, spic and span. The boys and girls like Fred. They like to help him keep the beach nice and clean. Fred, what do you want the children to find?"

Chart No. 3

Fred: "I want Nancy to find a (ball)."

Nancy finds a ball and gives it to Fred. Fred places ball in first slot of chart.

Fred: "Thank you, Nancy. John, find another (ball). Thank you, John."

Fred places plus sign in second slot and ball in third slot.

Fred: "I have one ball plus one ball. John, if I add one ball and one ball, how many balls will we have?"

John: "Two balls."

Fred places equal sign in the fourth slot and transfers the balls to the fifth and sixth slots.

Fred: "One ball plus one ball equals two balls. I will put the balls in the Lost and Found Box. I will put the plus sign and equal sign here. John, please help me find a (sea shell)."

The teacher plays the role of Fred's helper and models the dialogue until Fred is able to assume the role.

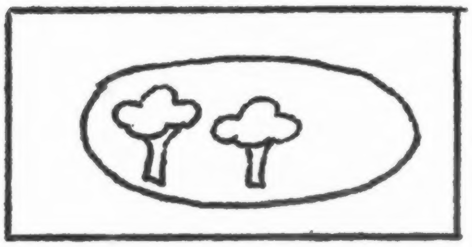
As the procedure becomes routinized, more objects may be used in the activity.

9. Unit II Program 5 Three

a. Objectives. Knowledge of the number three is taught in much the same manner as was the number two. The objective again is to teach the concept three, the formation of the numeral 3, and recognition of a set containing three objects.

The child goes through the process of increasing the number of objects or elements within a set before he is asked to think of the objects in terms of number. For example, the child has learned the concept of two, so in the program entitled three, the following procedure is followed:

Slide (1)

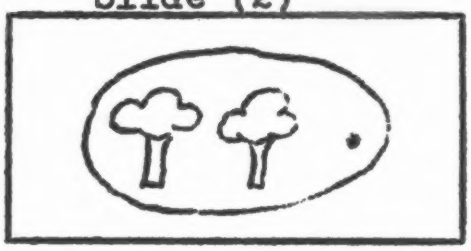


Frame 1.

Question: How many trees are there in this set?

Answer: There are two trees in this set.

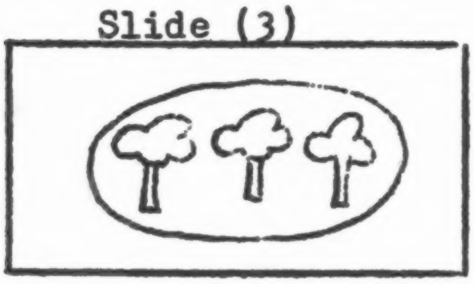
Slide (2)



Frame 2.

Question: Take a tree from your desk and place it over the blue dot.

Slide (3)



Frame 3.

You have two trees and you have placed one more tree.

Frame 4.

That makes three trees in this set. Two and one more is three.

Question: How many trees are there in this set?

Answer: Three.

It is not until the fourth slide in this progression that the child is asked to respond that there are three trees in this set. This concept of adding one object at a time to a set is used to teach the child each new number concept.

b. The criterion behavior is as follows: (1) Discrimination of numeral 3 by pointing; (2) Discrimination of set of three elements by pointing; (3) Identification of set of three elements by saying "three;" (4) Read the number phrase 2 + 1.

c. New Vocabulary: Three, how many more.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 65 slides, 56 teaching frames, 12 cue frames; (2) Responses: 21 motor, 35 verbal; (3) Manipulative Materials: One each of tree, dog, bird, fish, numeral 2, numeral 1. Two of numeral 3; (4) Time: 15 minutes.

e. The classroom activities include:

(1) Flannel Board

Materials: Flannelboard, flannel cutouts, three each of bunnies, birds, stars and discs.

Directions: As the cutouts are placed on board, by teacher or children, the children recite:

"Two little bunnies were very sad;
Then along came another,
And they were glad.

Two birds were sitting in a tree;
Down flew another,
And then there were three.

Two little stars up in the sky,
Joined another,
As it flew by.

Two discs were rolling around;
They saw another, (very softly)
Not making a sound."

(2) Making Sets of Three

Materials: Numeral cards 1, 2, 3, and 2 + 1.

Directions: Teacher: "John and Mary, make a set. How many are in this set?"

Response: "Two."

Teacher: "Who wants to join the set? Yes, Harry, you may join the set. How many are in the set now?"

Response: "Three."

Teacher: "John, please find the card with the numeral that tells how many are in the set." (John will choose either 3 or 2 + 1). "Fine. Now, Ann, will you show us another card that tells how many elements are in this set?" (Ann chooses the remaining card, either 2 + 1 or 3).

(3) Supplementary Activities: Three Billy Goats, Gruff; The Three Bears, and The Three Little Pigs can be read or dramatized.

10. Unit II Program 6 Same and Different Number

a. Objectives. This program is a good review of the programs in the first unit. The child is asked to recall the vocabulary, set, element, and match one-to-one, and the machine reinforces his behavior. The concept of matching one-to-one is then taken one step further to show its connection with numerals. The child is shown that if sets match one to one, they have the same number, but if sets do not match one-to-one, they have a different number. It is important for the child to understand and remember that the kind of elements in the sets is not important in setting up one-to-one correspondence or the same number of objects in several sets. In this manner, the child learns that each individual number or numeral has a meaning in itself and can stand by itself even though it is made up of different parts.

The innovation of this program is the introduction of new vocabulary (same and different numbers) and their meanings, in relation to sets and numbers.

b. The criterion behavior is as follows: (1) Completion of sentence, "If the elements of the sets match one to one, they have the (same number);"(2) Completion of sentence, "If the elements of sets do not match one to one, they have a (different number);"(3) Completion of sentence, "3 and 2 are (different numbers);" (4) Completion of sentence, "3 and 3 are (the same number)."

c. Vocabulary:

New Vocabulary: same number, different numbers.

Reinforce Vocabulary: Match one-to-one, do not match one-to-one.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 65 slides, 68 teaching frames, 10 cue frames; (2) Responses: 22 motor, 46 verbal; (3) Manipulative Materials: three bathing suits; (4) Time: 22 minutes.

e. The classroom activity includes:

(1) The Party

Materials: 20" x 30" chart (No. 4), three ice cream bars, two ice cream sandwiches, two ice cream sundae cups, freezer, two each of numerals 3, 2, and 1.

Suggested Narration by the Teacher: "It was a very hot afternoon in the summer. Jane was sitting on the steps in front of her house with her two friends, Jill and Joan. They were all trying to forget how hot it was by thinking of something cool.

'A snowman,' exclaimed Jill.

'A swimming pool,' said Joan, 'with me in it.'

'Ice cream for all of us,' suggested Jane. 'Let's go see if my mother has any for us.'

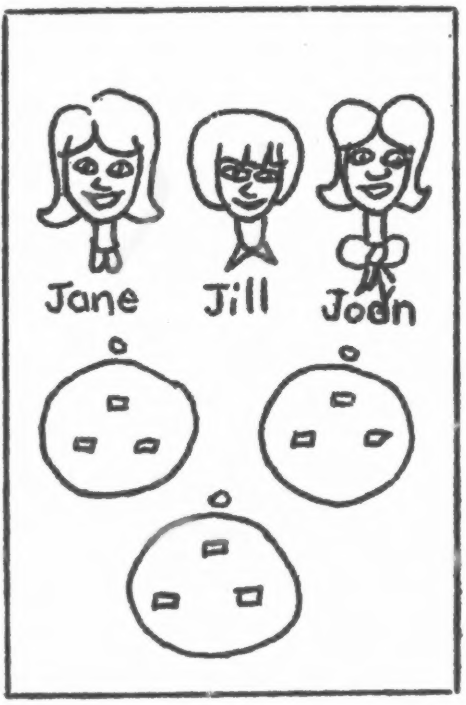


Chart No. 4

Jane's mother wasn't sure just what kind of ice cream was in the freezer, but she told the girls they were welcome to take whatever there was. Jane looked in the freezer and found three ice cream bars, two sundae cups, and two ice cream sandwiches.

Bill, give the ice cream bars to the girls. (Bill places a bar in the three sets.) Take the numerals and show the number attribute of each set.

Mary, how do the elements of the sets match?"

Mary: "The elements of the sets match one-to-one."

Teacher: "John, do the sets have the same or different numbers?"

John: "The sets have the same number."

Teacher: "Alice, one and one and one are the same or different numbers?"

Alice: "One and one and one are the same number."

Teacher: "I will remove the numerals. George, give sundae cups and ice cream sandwiches to the girls."(George distributes cups and sandwiches to the girls as he wishes, 3, 2, and 2; 3, 3, and 1; or 3, 2, and 2, in any pattern.)

Teacher: "George, take the numerals and show the number attribute of the sets. Tell us how the elements of the set match." (Complete sentence response.) "George, tell us if the numbers are the same or different." (Complete sentence response.)

Teacher: "I will remove the numerals. Tom, make the sets match one-to-one." (Any pattern acceptable, 1, 1 and 1, 2, 2 and 2). "Tom, take the numerals and show the number attribute of the sets. The sets match how?" (Complete sentence response). "How do the elements of the set match?" (Complete sentence response). "If the elements of sets match one-to-one, the numbers are what?" (Complete sentence response). "If the elements of sets do not match, the numbers are what?" (Complete sentence response).

Teacher: "Jerry, please remove the numerals, and the ice cream from the chart."

11, 12, 13. Unit II Programs 7, 8, and 9 More Than, Less Than, More Than-Less Than

a. Objectives. Program 7 (More Than), Program 8 (Less Than) and Program 9 (More Than-Less Than) are concerned with comparison of the numerals 1, 2, and 3. The objectives of all three of the programs are the same. Our first objective is to help the children develop an ability to compare two numbers. At this time, the child already understands that not all sets are equivalent and that numbers stand for different quantities. The task is to teach the child how to compare numbers so that he will understand the relationship between the numbers.

The child is taught to indicate his understanding of the idea of one number being greater or less than another number, by developing the use of a symbol to show that such a relationship exists. The child learns to use the > and < symbols with numbers only, and not with the sets themselves. When the child works with sets, he should say that one set has more elements or less elements than another set. It is important to remember that the relations symbolized by > and < do not express how much greater or less one number is than another. It merely states the relationship of more than or less than.

In the program, the child is asked to compare the number of elements that are in the sets before the actual numerals themselves are compared. The second step is to compare the numerals before the symbol is introduced to the pupil. When the symbol is introduced the child sees the symbol as it stands alone and he is taught the proper term for the symbol, either more than or less than. The child manipulates or writes the symbol in several cases before he is asked to write an entire number phrase using more than or less than.

At the end of these three programs, the goal is for the child to understand the concepts of more than and less than and to read and write the phrases and symbols which represent these two concepts.

b. The criterion behavior for Unit II, Program 7, More Than, is as follows: (1) Compare 3 and 1, 3 and 2, 2 and 1: (2) Read the number sentence,

$3 > 2$, $3 > 1$, $2 > 1$; (3) Write the number sentence, Three is more than two, etc.

The criterion behavior for Unit II, Program 8, Less Than, is as follows: (1) Compare 1 and 2, 1 and 3, 2 and 3; (2) Read the Statements, $1 < 2$, $1 < 3$, $2 < 3$; (3) Write the number sentence, "One is less than 2, etc."

The criterion behavior for Unit III, Program 9, More Than-Less Than, is as follows: (1) Place more than and less than symbols in comparing 1, 2, and 3; (2) Write more than and less than symbols in comparing 1, 2, and 3; (3) Read more than and less than sentences in comparing 1, 2, and 3.

c. New Vocabulary: compare, more than, less than.

d. The AVM Program inventory for Unit II, Program 7, More Than, is as follows: (1) Slides and Frames: 62 slides, 84 teaching frames, and 11 cue frames; (2) Responses: 30 motor, 54 verbal; (3) Manipulative Materials: Three more than signs, five each of whistles, pennies, and cameras; (4) Time: 18 minutes.

The AVM Program inventory for Unit II Program 8, Less Than, is as follows: (1) Slides and Frames: 62 slides, 79 teaching frames, seven cue frames; (2) Responses: 27 motor, 52 verbal; (3) Manipulative Materials: One less than sign, five each of pennies and flags; six whistles; (4) Time: 18 minutes.

The AVM Program inventory for Unit II, Program 9, More Than-Less Than, is as follows: (1) Slides and Frames: 58 slides, 75 Teaching frames, 21 cue frames; (2) Responses: 24 motor, 51 verbal; (3) Manipulative Materials: One each of less than sign, more than sign, the numerals 1, 2, and 3; (4) Time: 18 minutes.

e. The classroom activities include:

Program 7 More Than

Materials: Overhead projector, transparencies.

Directions: Project the transparencies on the screen as the children sing this rhyme to the melody of Ham Bone. Also, the teacher and/or pupils may write number sentences on the chalk board instead of using the projector.

First verse:
"More than, more than,
It's not new.
Showing three is more than two.

3 > 2

Refrain:
More than, more than,
More than.
This is the sign for more than.

>

Second verse:
More than, more than,
This is fun.
Showing two is more than one.

2 > 1

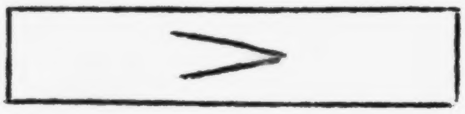
Refrain:
More than, more than,
More than.
This is the sign for more than.

>

Third verse:
More than, more than,
Do not run.
Show us three is more than one.

3 > 1

Refrain:
More than, more than,
More than.
This is the sign for more than."

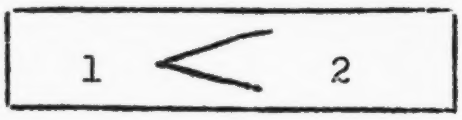


Program 8 Less Than

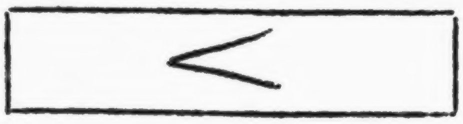
Materials: Overhead projector, transparencies.

Directions: Project the transparencies on the screen aa the children sing this rhyme to the melody of Ham Bone. Also, the teacher and/or pupils may write number sentences on the chalk board instead of using the projector.

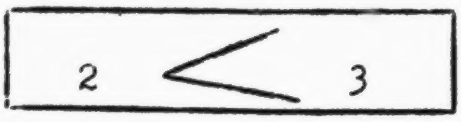
First verse:
"Less than, less than,
This is how you show that
One is less than two.



Refrain:
Less than, less than,
Less than.
This is the sign for less than.



Second verse:
Less than, less than,
This is how we show that
Two is less than three.



Refrain:
Less than, less than,
Less than.
This is the sign for less than.

$$\boxed{\quad < \quad}$$

Third verse:
Less than, less than,
This is how you show that
One is less than three.

$$\boxed{\quad 1 < 3 \quad}$$

Refrain:
Less than, less than,
Less than.
This is the sign for less than.

$$\boxed{\quad < \quad}$$

Program 9 More Than-Less Than

Materials: Overhead projector, 20 blank transparencies, 15 markers.

Directions: Divide class into two teams. Each team selects a captain. Distribute transparencies and markers.

Teacher: "We have been using the overhead projector to help us learn about more than and less than. I will whisper to each of you two numbers. You are to compare them and make a number sentence on the transparency. For example, I could say 'Compare the numbers two and one.' Since two is more than one, you would write the numeral 2, then the more than sign, and then the numeral 1. I will also accept the answer, 'One is less than two.' If you write both answers, you will earn double credit. Write your name on the transparency."

The teacher then whispers the two numbers to each child.

Captains A and B alternate in projecting the transparencies. Each child stands and reads his sentence. Team with highest score wins.

Teacher projects transparency.

$2 > 1$ $2 < 3$

Response:
"Less than, more than.
Say it with me.
Two's more than one,
But less than three."

$3 > 1$ $3 > 2$

Continue:
"More than, more than,
Here's a cue,
Three's more than one,
Three's more than two."

14. Unit II Program 10 Counting and Enumeration

a. Objectives. After completing the previous program, the child has become familiar with many new concepts. This particular program acts as a review as it does not introduce or teach any new concepts to the child, but it does attempt to tie together all the concepts that the child has learned. By practicing counting aloud and enumerating the numbers in sequential order, the child experiences the natural order of whole numbers. The objective is to teach the pupil to count aloud numbers in relation to the number of objects in a specific sequence. In this way, the child may recognize the relationahip between the concept of number and a set which displays a certain number of objects. The numeral which the child writes or refers to stands as a representation of the actual number concept.

b. The criterion behavior is as follows: (1) Count aloud three objects presented sequentially and in a group; (2) Place numerals which identify sets of one, two, and three elements.

c. New Vocabulary: Less, count.

d. The AVM Program inventory includes: (1) Slides and Frames: 79 slides, 51 teaching frames, one cue frame; (2) Responses: ten motor, 45 verbal;

(3) Manipulative Objects: three fish, six blocks, one each of numerals 1, 2, and 3; (4) Time: ten minutes.

e. The classroom activities include:

(1) One, Two, Three

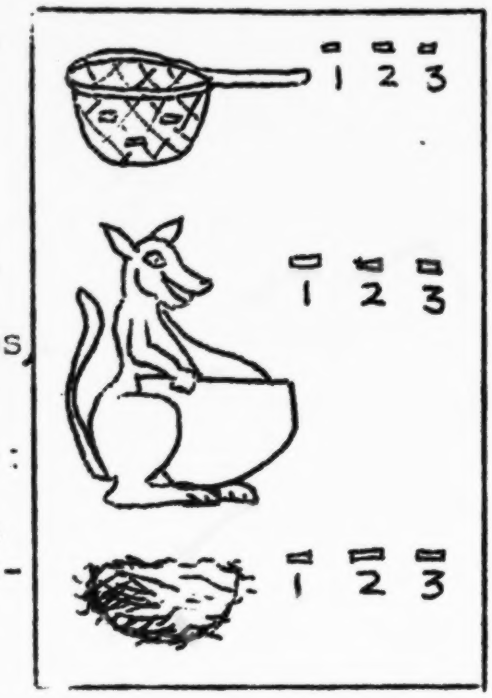


Chart No. 5

Materials: 20" x 30" chart (No. 5), three each of butterflies, baby kangaroos, and birds.

Directions: Teacher: "John, please place the butterflies on the chart. Count the butterflies as you place them on the chart. Thank you. I will read the verse for you to show you how we play:

One little butterfly caught
in the net,
(Moves first butterfly to the
net)
In flew another
(Transfer the second butterfly)
And there were two in the set.
One, two, oh, dear me!
Here comes another
(Transfer third butterfly)
And that makes one, two, three!"

Teacher: "John, you may remove the butterflies. Mary, place the kangaroos on the chart. Count the kangaroos as you place them on the chart. Thank you. I will read the verse for you:

Lou Kangaroo had a pocket,
Didn't know how she could lock
it.
She went to sleep beneath a tree
In hopped her babies, one, two,
three!"
(Transfers kangaroos)

Teacher: "Mary, you may remove the kangaroos. Bill, place the birds on the chart. Count the birds as you place them on the chart. Thank you. I will read the verse for you:

One happy bird is in the nest;
(Transfer bird)
Another came to take a rest.
(Transfer bird)
They weren't alone for very long,
Another came to sing their song.
(Transfer bird)
One, two, three!

Bill, you may remove the birds."

(2) Flannel Board

Materials: Cutouts of ten apples, three numerals of 1, 2, and 3.

Directions: Place apples randomly on board in sets of 3, 3, 3, 1; 3, 3, 2, 2; 3, 2, 2, 2, 1; 3, 2, 1, 3, 1 and 3, 2, 2, 1, 1, 1. As each series is presented, have children place numerals which tells how many apples are in each set.

15. Unit II Program 11 Pre Post Test

a. The AVM Program inventory includes: (1) Slides and Frames: 52 slides, 26 cue frames, 58 criterion frames; (2) Responses: 29 motor, 29 verbal; (3) Manipulative Materials: One sign each of plus, equal, more than, less than; three each of fish and apples.

16. Unit III Program 1 Zero

a. Objectives. The concept of zero is an essential and fundamental one to the development of an early arithmetic program. Since the concept is abstract, however, it was decided to provide some experience in recognizing the cardinal number of sets and associating numerals with sets before introducing zero and empty sets. Therefore, the program zero follows the development of numbers through three in the programming sequence.

The prime objectives of this program are to enable the children to recognize empty sets, to understand the meaning of zero and to associate it with empty sets, and to understand that zero is less than one and one is more than zero.

To accomplish these objectives, the program begins by exposing the children to some empty sets and to the numerical order of numbers 0 through 3. In the early development it is explained that zero and its numerical 0 characterize empty sets. The child is subsequently asked to discriminate the numeral 0 among other numerals and to distinguish which of two sets is empty and then which of several sets, by writing the numeral 0 below the empty sets. The elicited verbal responses, "empty set," and "zero" add to the students' vocabulary.

The association of the number zero with empty sets should not detract from its importance for the child as a whole number. For this reason, it is stressed in the program to be a number, and the word "nothing" is not used descriptively. Moreover, comparisons are drawn between zero and other numbers to make the child aware of zero's place in the set of whole numbers.

b. The Criterion Behavior is as follows: (1) Draw lines around the numeral that describes an empty set; (2) Write numeral that describes an empty set; (3) Complete statement, "If there are no elements in a set, the set is (an empty set;)" (4) Complete statement, "The number that describes an empty set is (zero)."

c. New Vocabulary: zero, empty set, number attribute.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 39 slides, 72 teaching frames, 13 cue frames; (2) Responses: 59 motor, 13 verbal; (3) Manipulative Materials: three dogs; (4) Time: 27 minutes.

e. The Classroom activities include:

(1) What is the Number?

Materials: Four containers, six beads, one each of 4" x 5" numeral cards 0, 1, 2, and 3.

Directions: Place one, two, and three beads in three containers respectively, leaving the fourth container empty.

Teacher: "John, come up and select a container and count the number of beads to see how many elements are in the set."

John: "There are two beads in the set."

Teacher: "Find the numeral that describes the number attribute of the set and place it by the container."

Continue with containers containing beads. Present empty container last.

Teacher: "Ann, come up and count the beads in this set."

Ann: "The set is empty."

Teacher places the numeral zero by the container.

Teacher: "This is the numeral zero. Zero is the number attribute of an empty set."

Always refer to the zero numeral as zero; never use "oh."

(2) Flannel Board

Materials: Flannel board, two each of flannel cutouts: star, triangle, cat, dog, bird, the numerals 0, 1, 2, and 3; six circles to designate sets.

Directions: Place four circles on board. Randomly distribute cutouts, objects, and numerals to the children. Request children to place elements in the sets, no more than three elements to any set. Request children to place the numerals that describe the number attribute of the sets. Place fifth circle on board. Place the numeral zero under this set.

Teacher: "This is an empty set. The numeral zero describes the number attribute of the empty set."

Modify procedure as children develop skills. This may be presented as a game activity. Team A presents sets on board; Team B places numerals; Teams A and B alternate in placement of elements and numerals.

(3) What is the Number Attribute?

Directions:

Name set in classroom and give number attribute. Restrict number of elements in set to three elements. What is the number attribute of the set of clocks in the room? What is the number attribute of set of live elephants in the room? Zero.

17. Unit III Program 2 Four 3 + 1

a. Objectives. The objectives outlined apply to Unit III Program 2 3 + 1 as well as to Unit III Program 3 2 + 2.

There is a continuum in the sequence of whole numbers, i.e., each new number is derived by adding one more to its predecessor. In the programs, therefore, the introduction of the concept of four follows in this manner. The child has learned to recognize sets of one, two, and three, and is ready to learn the next sequential number.

The aim of the two programs entitled Four is to teach the meaning of the number concept. Therefore, the first of these programs develops from the idea of one-more and the second from the principle that a set of four can be divided in two subsets each containing two elements. In the first of these programs the child also becomes familiar with the formation of the numeral 4 and receives practice in distinguishing sets with four elements. Just as he has learned to associate the numeral 4 with four elements in a set, he also learns to associate more precise symbols to characterize sets of four, i.e., 3 + 1 and 2 + 2. This is accomplished by first having the child build a set of three and one more, then placing the numeral 4 with it and enabling him to discover that 3 + 1 is another way of referring to the numeral 4. Likewise the similar development of 2 + 2 illustrates that this is yet another way of saying four. Finally, the development progresses to equating these two number combinations with the numeral 4 in the form of number sentences, i.e., 3 + 1 = 4 and 2 + 2 = 4.

An overall objective of the programs is to help the children to think flexibly about number concepts. Consequently in addition to having the pupil think merely in terms of joining sets and adding numbers, the concept of the missing addend has also been interwoven into the activities of the number programs. He is asked, for example, how many more elements would have to be put with a set of three to make a new set of four. One of the addends and the sum are made known; the child must determine the missing or unknown addend. In another instance, or frame of the program, he is asked to supply the other missing addend. In this way, the child is guided to examine a number sentence from different angles, and will begin to see relations between numbers. There is an added advantage to this approach as the pupil is being indirectly exposed to the concept of subtraction.

b. The criterion behavior is as follows: (1) Discrimination of the numeral 4 by pointing to it and by placing the numeral 4 over the four projected on the screen; (2) Place single numerals, the plus and equal sign in placeholders to complete all combinations of the number sentence 3 + 1 = 4; (3) Read number sentence 3 + 1 = 4.

c. New Vocabulary: four, 3 + 1 = 4.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 65 slides, 40 teaching frames, 14 cue frames; (2) Responses: 18 motor, 22 verbal; (3) Manipulative Materials: One each of apple, bird, soda bottle, fish, the numerals 4, 3, 2, and 1; two each of cat, dog, and cones; (4) Time: eight minutes.

e. The classroom activities include:

(1) Flannel Board

Materials: Flannel board, flannel cutouts, two each of 12 different figures, the numerals 0, 1, 2, 3, and 4, plus, equal, and place holder signs.

Directions: Place set of three elements on board with numeral 3 underneath. Pick up one more element, the numeral 1, and one plus sign. Explain that as one element is placed in set of three elements the plus sign and the numeral 1 describes the placement. Place element in set and complete the number phrase 3 + 1. Read number phrase. Remove 3 + 1. Request a child to place a single numeral that describes the number attribute of the set on the board. Remove cutout.

Place one set of four elements on left of board with phrase 3 + 1, as described above. Place another set of 4 elements, with the numeral 4, on right of board. The number attribute of both sets is four. Request child to place a sign to show that the number attributes of the sets are equal. Remove cutouts.

Place number sentence 3 + 1 = 4 on board. Request child to place figure cutouts on board to illustrate the number sentence.

As skills develop, selected Team A and B may alternate in placing sets and number sentences on board. The placeholder may be substituted for the numerals and signs of the number sentences. Teams A and B alternate in placing correct numerals or signs in the placeholder.

(2) Puzzle

Materials: Puzzle sheets, green crayons.

Directions: Distribute puzzles, and crayons. Say, "There is an animal hidden on this paper; see if you can find it. Color only the spaces numbered 4 and you will find the animal."

18. Unit III Program 3 Four 2 + 2

a. Objectives. Same as Unit III Program 2.

b. The criterion behavior is as follows: (1) Place single numerals, the plus sign and equal sign in placeholders to complete all combinations of the number sentence 2 + 2 = 4; (2) Read the number sentence 2 + 2 = 4.

c. New Vocabulary: 2 + 2 = 4.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 56 slides 34 teaching frames 13 cue frames; (2) Responses: 18 motor, 16 verbal; (3) Manipulative Materials: Same as Unit III, Program 2; (4) Time: Eight minutes.

e. The classroom activities include:

(1) Picture Rhymes

Materials: 8" x 10" cards, Cloud Card 3 + 1 = , Billy Goat card 3 + 1 = , Pig Card with numeral 4, Pig Card with phrase 2 + 2.

Directions: Rhyme:
"There once were handsome piggies four,
Who tried at once to pass the door.
(Present numeral 4 Pig Card)
Said the smartest of these,
'This is too tight a squeeze.'
(Present numeral 2 + 2 Pig Card)
Two by two is better than four."
(Child places numeral 4 on card).

The class reads 2 + 2 = 4.

Rhyme:
"Three billy goats
In bright red coats
Were looking for
Their breakfast oats.
(Present Billy Goat Card)
Another came to find the store
So 3 + 1 will equal four."
(Child places numeral 4 on card).

The class reads 3 + 1 = 4.

Rhyme:
"Three clouds were quiet,
Did not roar.
(Present cloud card)

Another came
And that made four."
(Child places numeral 4 on card.)

The class reads 3 + 1 = 4.

19. Unit III Program 4 Five 4 + 1, 3 + 2

a. Objectives. In presenting the concept of five, the number is again approached by the one-more pattern. To orient the child's thinking in these terms, he will first view the number of this new set as four and one more. 4 + 1 helps the child to visualize the relation between a set of four and a set of five, i.e., five is one more than four.

As in the development of the other number programs, the standard label or numeral 5 is first applied to the set. The child develops the ability to recognize sets of five and to verbalize the number. After this he is ready to associate more complex symbols for five, i.e., 4 + 1, and 3 + 2. The latter of these is the more difficult combination to grasp. To guide the child's understanding of the concept, he is shown that within a given set there are two sets, i.e., 3 and 2, which were joined to form this set of five. He is given practice in joining sets of three and two. Also opportunity is provided for the pupil to explore this number combination by different approaches, i.e., by varying the missing addend in different frames. The child is expected to read the number combinations. The order relation of five is emphasized by comparing it to other whole numbers.

b. The criterion behavior is as follows: (1) Give the number attribute of a set of five elements; (2) Discriminate pairs of sets of four and four elements, five and five elements, as having the same or different number; (3) Identify numeral 5 by pointing and writing; (4) Name single numerals and signs to complete the number sentence 4 + 1 = 5, 3 + 2 = 5; (5) Place and write single numerals and signs to complete all combinations of the number sentence 4 + 1 = 5, 3 + 2 = 5.

c. New Vocabulary: Five

d. The AVM Program inventory is as follows: (1) Slides and Frames: 66 slides, 82 teaching frames, 15 cue frames; (2) Responses: 32 motor, 50 verbal; (3) Manipulative materials: One each of the numerals 5, 4, 3, 2, and 1, bird, house, five rabbits, two dogs, plus and equal signs; (4) Time: 25 minutes.

e. The classroom activities include:

(1) Flannel Board

Materials: Five each of stars, birds, and apples, one each of the numerals 0, 1, 2, 3, 4, and 5, equal sign and plus sign.

Directions: Verse:
"Four apples fell from off the tree,
(Place four apples in set; place numeral 4 under the set)
One more fell off,
(Place one more apple in set; place plus sign and numeral 1 on board)
And that makes five as you can see."
(Place equal sign and numeral 5 on board)

Unison response:
"4 + 1 = 5."

Verse:
"One apple fell from off the tree.
(Place apple and numeral 1 on board)
Four more fell off,
(Place four more apples, plus sign, and numeral 4)
And that makes five as you can see."
(Complete number sentence)

Unison response:
"1 + 4 = 5."

(Continue with 3 and 2, 2 and 3).

Verse:
"Four stars were twinkling in
the sky,
(Place four stars in set and the numeral 4 on board)
One more came out
(Place plus sign and numeral 1 on board)
I wonder why!"
(Complete number sentence. Continue with all combinations.)

Unison response: "4 + 1 = 5."

Verse:
"Five little birds were in a
nest.
(Place five birds on board, also numeral 5)
No more joined them,
(Place plus sign and numeral 0 on board)
So they took a rest."
(Complete number sentence.)

Unison response: "5 + 0 = 5."

(2) Joining Sets

Materials: 8" x 10" cards, five each of horses and cows.

Directions: Have four children each take a horse card and stand together; have one child take a cow card and stand alone.

Teacher: "How many horses are in the horse set?"

Response: "There are four horses in the set."

Teacher: "How many cows are in the cow set?"

Response: "There is one cow in the cow set."

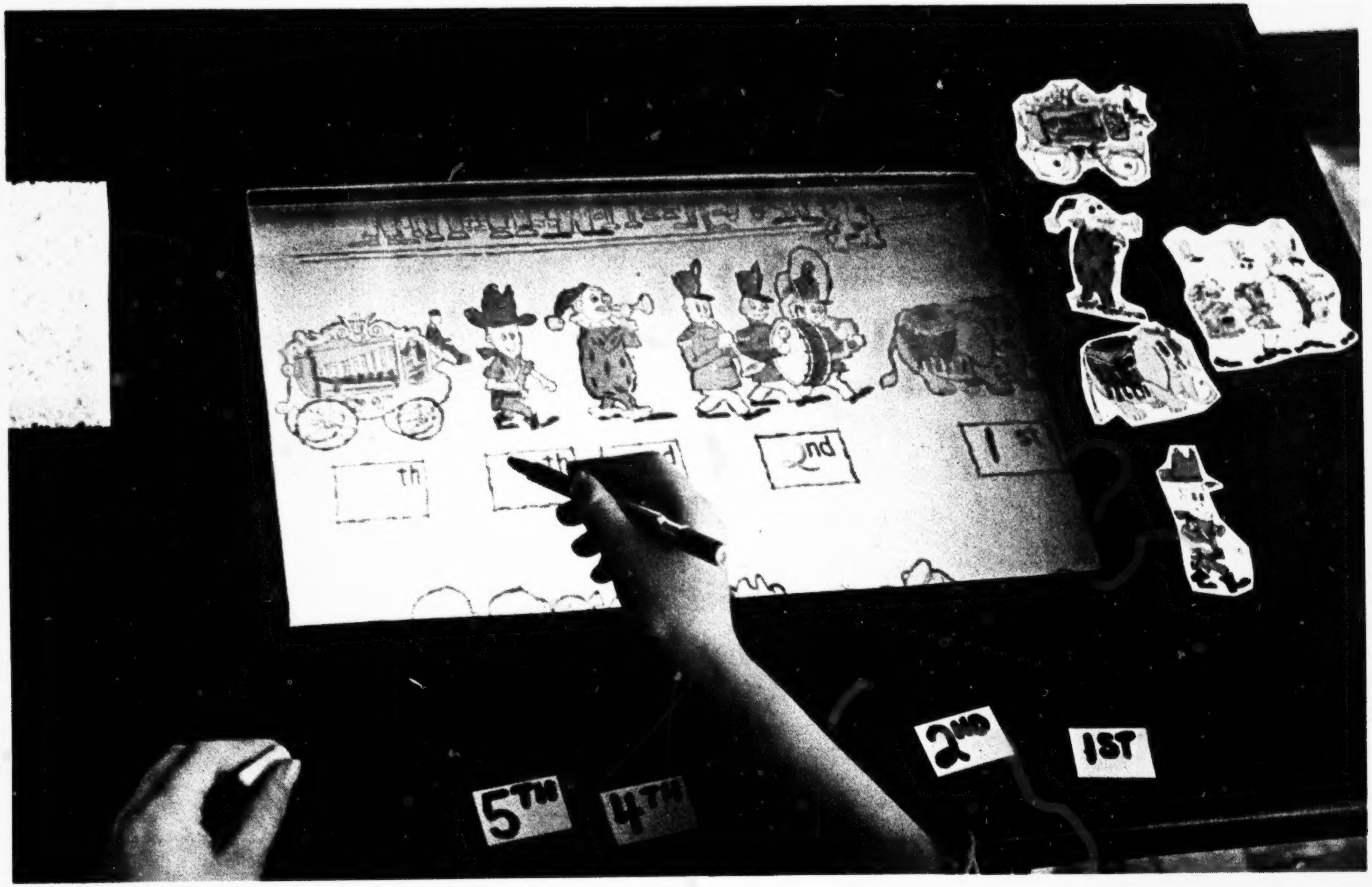


Figure B-3. WRITING ON THE RESPONSE SURFACE

Teacher: "Let us join the sets." (The children walk together.) "How many elements are in the set?"

Response: "There are five elements in the set."

Teacher: "Can you think of a number sentence that describes the joining of the sets?"

Response: "4 + 1 = 5." (As the sentence is stated, the sentence is written on the board.) Repeat the activity with differing number of horses and cows, using 3 + 2 = 5, 2 + 3 = 5, 4 + 1 = 5, 1 + 4 = 5, 5 + 0 = 5.

20. Unit III Program 5 More Than-Less Than

a. Objectives. This is an extension of the process in comparing 1, 2, and 3 as More Than-Less Than, Unit II, Programs 7, 8, and 9.

b. The criterion behavior is as follows: (1) Read more than and less than comparative sentences in combinations of three, four, and five; (2) Place correct symbols in placeholder in comparative sentences in combinations of three, four, and five; (3) Write comparative sentences in combinations of three, four, and five.

c. Reinforce Vocabulary: More than, less than.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 56 slides, 55 teaching frames, 20 copy frames; (2) Responses: 25 motor, 30 verbal; (3) Manipulative Materials: Five oranges, three more than-less than signs; (4) Time: 22 minutes.

e. The classroom activities include:

(1) Rhymes

Materials: One transparency of more than-less than signs; five transparencies--each transparency has combinations of two different animals; overhead projector.

Directions: Say or sing (to melody of Ham Bone) the following rhymes, while projecting the corresponding transparencies on the screen. (When each more than or less than comparison is stated, the overlay for comparison is placed in the proper position.)

Verse:
"More than, more than,
Say it with me.
Five is more than four.
Five is more than three.

$5 > 4$

$5 > 3$

More than, more than
This is how we
Show that four
Is more than three.

$4 > 3$

Less than, less than,
Bees in a hive.
Four bees are always
Less than five.

$4 < 5$

Less than, less than
Keep it gay
Three is less than five,
That's all for today.

$3 < 5$

(2) Game: More than-Less Than

Directions: Divide the chalkboard into two sections; divide the class into two teams. If there is an odd number of children, one child becomes the time keeper. Each team stands in a line facing the board; the children stand one behind the other. Write as many pairs of two numerals in each section as there are members of a team. Leave room between each pair for writing the more than or less than sign.

Teacher: "We are going to play a game to see which team can place the most more than and less than signs correctly between these numbers. Speed and accuracy count. When a player is finished, he should raise his hand, and I will check his work. If it is correct, he may sit down. If it is incorrect, he will go to the end of the line, and the next player will correct the work. The first team to sit down is the winning team, 'The Team of Champions.'"

(3) The children write their names on the transparencies. The teacher whispers a comparative sentence to each child. The children write the sentences on the transparencies. A record of whispered comparisons should be kept so that accuracy may be insured. Each child projects and reads his sentence.

21. Unit III Program 6 Counting and Enumeration

a. Objectives. This is a review program and brings together concepts which have been taught in previous programs. The counting process is presented in a meaningful way. Refer to Unit II Program 6, Counting and Enumeration.

b. The criterion behavior is as follows: (1) Count the number of elements in sets of one to five elements; (2) State the number attribute of sets having one to five elements; (3) Write the number attribute of sets having one to five elements.

c. Reinforced Vocabulary: Less, number attribute.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 69 slides, 62 teaching frames, three cue frames; (2) Responses: 8 motor, 54 verbal; (3) Manipulative Materials: Five cars, four radios, one each of numerals 3, 4, and 5; (4) Time: ten minutes.

e. The classroom activities include:

(1) Pony Game

Materials: Three each 8" x 10" cards of the numerals 1, 2, 3, 4, and 5.

Directions: Divide class into sets of six children. One child is the ringmaster; the other children are given numeral cards 1 to 5. They form a circle around the ringmaster. There are as many circles as there are sets of six children. The ringmaster calls any number from 1 to 5. The child with the number steps forward and taps his foot the number of times corresponding to the number called. If correct, the pony gallops around inside the ring and back to his place. If he is wrong, he returns to his place at once. As the pony taps, the children count the number of taps.

(2) How Many?

Materials: Two sets of numeral cards, 1 through 5.

Directions: Two teams are selected. Each member is given a numeral card which is suspended across the shoulders with the back side of the card exposed. Each child keeps his numeral a secret.

Team A:	John	Ann	Sally	Joe	Mary
	3	1	5	4	2

Team B:	Bill	Tom	Agnes	Harry	Andy
	4	3	1	2	5

John claps three times, asks, "How many?"	1 point
Bill says, "The number is three."	1 point
Ann claps two times, asks, "How many?"	0 point
Tom says, "The number is two."	1 point

(3) May I?

Directions: The leader stands on a certain mark and the other players stand in a line on the opposite side of the room. The leader tells each in turn how many and what kind of steps he may take. If a child fails to ask "May I?" he must go back to the beginning.

Leader: "John, you may take four baby steps."

John: "May I?"

Leader: "Yes you may."

John: (takes four baby steps.)

Leader: "Mary, you may take three giant steps."

Mary: "May?"

Leader: "No, you may not. You may take one giant step."

Mary: "May I?"

Leader: "Yes, you may."

The kind of steps may include tiny, average, big, little, elephant, etc.

22. Unit III Program 7 Ordinals 1st-3rd

a. Objectives. The objectives of the ordinal programs are to develop skills by which the child may identify the order or position of objects or events in time and space. The development of this concept takes the form of two teaching programs, i.e., Ordinals First-Third and First-Fifth.

In the first of these programs, the superscripts are given and the child is cued in the formation of ordinals. He is taught in a formal sense the names of various positions of a row of objects. These names he probably has already informally experienced. These names or ordinals are now stressed in connection with the relative position of an object in an ordered set. The second program extends practice in recognizing ordinal numbers by not only having the child write numerals with corresponding given superscripts but also by having them place three-dimensional ordinals with respective ordered objects.

b. The criterion behavior is as follows: (1) Write ordinal numerals to indicate ordinal position in time and space; 1st, 2nd, and 3rd, superscript given; (2) verbally identify ordinal position in time and space; (3) completion of "If you know the position or order, you know (the ordinal number);" (4) completion of "If you know the ordinal number, you know (the order and/or position)."

c. New Vocabulary: First, second, third, order, ordinal number and position.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 56 slides, 61 teaching frames, 11 cue frames; (2) Responses: 18 motor, 43 verbal; (3) Manipulative Materials: One each of ordinals, 1st, 2nd, 3rd; (4) Time: 12 minutes.

23. Unit III Program 8 Ordinals 1st-5th

a. Objectives. See Program 7, Ordinals 1st-3rd.

b. The criterion behavior is as follows: (1) Write ordinal numerals to indicate position in time and space, 1st-5th superscripts given; (2) verbally identify ordinal position in time and space, 1st-5th.

c. New Vocabulary: Fourth, fifth.

d. The AVM Program inventory is as follows: (1) Slides and Frames: 35 slides, 61 teaching frames, 11 cue frames; (2) Responses: 18 motor, 43 verbal; (3) Manipulative Materials: One each of ordinals 1st-5th, one each of band, calliope, elephant, cowboy, and clown; (4) Time: 25 minutes.

e. The classroom activities.

The classroom activities are presented for Program 8, Ordinals 1st-5th. These activities may be adapted to Program 7, Ordinals 1st-3rd, be eliminating reference to the ordinals 4th and 5th. The classroom activities include:

(1) Bus Game

Materials: Five 8" x 10" bus stop signs, four each of bus tokens with ordinal numbers 1st to 5th.

Directions: Attach the five bus stop signs to chairs set at wide intervals around the room. Select a bus driver. He stops at each chair to discharge and take on passengers. The passengers stand in a single line behind the driver. Distribute a token to each child. By matching the ordinal number on the token with the ordinal number of the bus stops, the child determines where he gets on and off the bus. The children waiting at a bus stop sing the following to the tune of "Did You Ever See a Lassie?" substituting the proper ordinal for the bus stop where he is waiting:

"I am waiting at the first bus stop,
First bus stop,
First bus stop.
I am waiting at the first bus stop.
Please let me on."

When he gets on, he moves to the back of the line; as the bus approaches the child's stop, he sings:

"I get off at the third bus stop,
Third bus stop,
Third bus stop.
I get off at the third bus stop.
Please let me off."

Remind the children it is polite to wait for a person getting off the bus before boarding it yourself. Introduce the game by having all the children get on and off the bus at one stop. When the children become familiar with the procedures, the tokens may be distributed randomly.

(2) School Days

Materials: Five 8" x 10" cards, 1st Monday, 2nd Tuesday, 3rd Wednesday, 4th Thursday, and 5th Friday.

Activity: On Monday, introduce 1st Monday card to the class. Explain that Monday is the first day of the school week. Follow same procedure on successive school days. After cards have been introduced, display cards on chalk rail. Ask these questions: "What is the ordinal number of the first day of the school week?" "What is the name of the first day of the school week?" Continue with other cards sequentially and later in random order.

Later, distribute cards randomly to five children. Have other children place the children in the correct order of the school week and explain the position, e.g., "Mary is Monday; I will place Mary first in line."

24. Unit III Program 9 Pre Post Test

a. The AVM Program Inventory is as follows: (1) Slides and Frames: 27 slides 53 criterion frames, 13 cue frames; (2) Responses: 17 motor, 36 verbal; (3) Manipulative Materials: One each of numerals 1-5; (4) Time: 12 minutes.

III. Assessment Techniques

A. Pre Post Test (AVM Test)

There is a Pre Post Test for each of the three units. When assessment is made prior to exposure to the programs of a unit, the test is referred to as the Pre Test; when assessment is made following exposure to the programs of a unit, the test is referred to as the Post Test. The difference score of the Pre and Post Tests indicate the effectiveness of the programs in teaching the concepts of the unit.

The frames or items of the AVM Test are designed to elicit the criterion behavior listed for each program. In fact, the AVM Test and the program scripts were developed at the same time so that the instructional objectives and content of programs would be assessed by the test. However, no prompts or reinforcements, visual or auditory, are used in the AVM Test. With a few unavoidable exceptions, the test items were similar to but not identical to the frames of the teaching programs. This forestalls the possibility of memorizing responses to specific instructional frames and emitting these responses in the exact context of the instructional programs.

While the assessment of the teaching programs is a major function of the Pre Post Test, the Pre Test is helpful in the prescription of programs for remediation. When only a few of the concepts of a unit are unknown, analysis of the Pre Test responses would indicate which programs should be administered. The programs present a sequential development so that if a child has minimal errors on any particular unit test, the programs of that particular unit would not be presented but the Pre Test of the subsequent unit would be administered.

The administration and scoring of the AVM Test is straight forward. Column 1 of the Evaluation Record lists the frame numbers of the Test; column 2 lists the overt response for the respective frames; column 3 indicates that the response is motor (M) or verbal (V); correct responses are checked in column 4 and incorrect responses or other comments are entered in column 5. The Evaluation Records for the Unit I, Unit II, and Unit III AVM Tests follow:

Unit I Pre Post Test

Artifacts: One each of cherry, pear, fork, spoon, and red block; two each of apples and toy cars.

Name________________
Teacher______________
School_______________
Date________________
Possible correct score: 21

Frame	Overt Response	M or V	Elicit	Comment
1	draw ring--bananas	M		
2	set	V		
3	erase		no credit	
4	set	V		
5	make set--apples (any no.)	M		
6	return apples		no credit	
7	set (of hammers)	V		
8	set (of shoes)	V		
9	fork--inside ring	M		
10	return fork		no credit	
11	apple, spoon, red block, inside ring	M		
12	return objects		no credit	
13	an element	V		
14	cars--inside ring	M		
15	element (of the set)	V		
16	return the cars		no credit	
17	no	V		
18	a fish	V		
19	X over blue element	M		
20	erase		no credit	
21	match one to one	V		
22	do not match one to one	V		
23	one to one	V		
24	one	V		
25	draw lines between elements	M		
26	erase		no credit	
27	do match one to one	V		
28	erase (optional)		no credit	
29	do not match one to one	V		
30	erase (optional)		no credit	

Error Score _______

Unit II Pre Post Test

Artifacts: Numerals 1, 2, and 3; one each of blue, red, and green fish; three apples; the symbols plus, equals, more than, less than.

Name________________
Teacher______________
School_______________
Date________________
Possible correct score: 58

Frame	Overt Response	M or V	Elicit	Comment
1	one	V		
2	draw x over one element	M		
3	erase		no credit	
4	place 1 over set of one element	M		
5	clear surface		no credit	
6	write 1	M		
7	erase		no credit	
8	two	V		
9	circle 2	M		
10	erase		no credit	
11	make set of two fish	M		
12	clear surface		no credit	
13	write 2	M		
14	erase the surface		no credit	
15	point set--two elements	M		
16	write + symbol	M		
17	erase		no credit	
18	one plus one	V		
19	point 2	M		
20	point =	M		
21	write =	M		
22	erase		no credit	
23	place + and = symbols	M		
24	return symbols		no credit	
25	one plus one equals two	V		
26	two	V		
27	write 2	M		
28	erase		no credit	
29	one plus one	V		
30	1 + 1	M		
31	erase		no credit	
32	write 2	M		
33	erase		no credit	
34	three	V		
35	write 3	M		
36	erase		no credit	
37	make set of 3 elements	M		
38	return objects		no credit	

Unit II Pre Post Test(continued) Name______________

Frame	Overt Response	M or V	Elicit	Comment
39	write 3	M		
40	erase		no credit	
41	one plus one equals three	V		
42	erase		no credit	
43	add one apple	M		
44	place 1 in box	M		
45	return objects		no credit	
46	number	V		
47	different	V		
48	write 2's	M		
49	same	V		
50	erase		no credit	
51	different	V		
52	write >	M		
53	erase		no credit	
54	more	V		
55	(two is) more than one	V		
56	three is more than one	V		
57	place > symbol	M		
58	clear surface		no credit	
59	more than one flag	V		
60	write > symbol	M		
61	erase		no credit	
62	3 > 2	M		
63	erase		no credit	
64	less	V		
65	less than two	V		
66	place < symbol	M		
67	clear surface		no credit	
68	write < symbol	M		
69	two is less than three	V		
70	erase		no credit	
71	less than two flags	V		
72	one is less than three	V		
73	2 < 3	M		
74	erase		no credit	
75	one	V		
76	two	V		
77	three	V		
78	one	V		
79	two	V		
80	three	V		
81	write 1, 2, 3 in boxes	M		
82	erase		no credit	
83	how many	V		
84	the number	V		

Error Score ______

Unit III Pre Post Test

Artifacts: the numerals 1, 2, 3, and 4.

Name________________
Teacher______________
School_______________
Date________________
Possible correct score: 53

Frame	Overt Response	M or V	Elicit	Comment
1	write number attribute each set	M		
2	empty set	V		
3	erase		no credit	
4	circle O's	M		
+ 5	zero	V		
6	erase		no credit	
7	more than zerc	V		
8	less than zero	V		
9	different	V		
10	four	V		
11	place 4	M		
12	three plus one equals four	V		
13	three	V		
14	place 3	M		
15	three plus one equals four	V		
16	one	V		
17	place 1	M		
18	three plus one equals four	V		
19	clear surface		no credit	
20	two	V		
21	place 2	M		
22	two plus two equals four	V		
23	clear surface		no credit	
24	3	V		
25	write 3	M		
26	erase		no credit	
27	1	V		
28	write 1	M		
29	erase		no credit	
30	2	V		
31	write 2	M		
32	erase		no credit	
33	4	V		
34	write 4	M		
35	erase		no credit	
36	less than 4	V		
37	more than 3	V		
38	more than 3	V		
39	less than 5	V		

Unit III Pre Post Test(continued) Name______________

Frame	Overt Response	M or V	Elicit	Comment
40	five is more than four	V		
41	three is less than five	V		
42	place < sign	M		
43	return sign		no credit	
44	write 3 < 5	M		
45	erase		no credit	
46	write number attribute of each set	M		
47	erase		no credit	
48	number (attribute)	V		
49	how many	V		
50	the number	V		
51	second	V		
52	third	V		
53	first	V		
54	write respective positions M-3rd	M		
55	J-1st	M		
56	B-2nd	M		
57	erase		no credit	
58	ordinal number	V		
59	order: written symbols	M		
60	clear surface		no credit	
61	second	V		
62	fifth	V		
63	fourth	V		
64	third	V		
65	first	V		
66	order or position	V		

Error score______

B. The Criterion Test

The Criterion Test is an independent measure of the concepts a pupil has gained via the programmed instruction. Like the Post Test, the Criterion Test assesses how well the programming sequence has met its outlined objectives. However, unlike the Post Testing, this evaluation is removed from the context of the teaching machine. It is administered individually by an examiner in approximately ten minutes.

The Criterion Test was constructed to investigate if a subject could transfer concepts learned on the machine and apply them to independent tasks. Where the Post Test asks for only those kinds of responses elicited in the program, the Criterion Test calls for more complex tasks.

The directions for the administration of the Criterion Test are:

CRITERION TEST
DIRECTIONS AND RECORD FORM

Name____________________ CA____ MA_____IQ_____
Teacher__________________
School___________________
Date____________________ Total Score__________

1. Present Diagram 1. Say: "Now listen carefully and finish these sentences." E points to the two sets. a. "The objects in this picture form . . . (sets)." b. "The apple in this picture is called . . . (an element)." c. "The elements in these sets match . . . . (one-to-one)."

3 credits

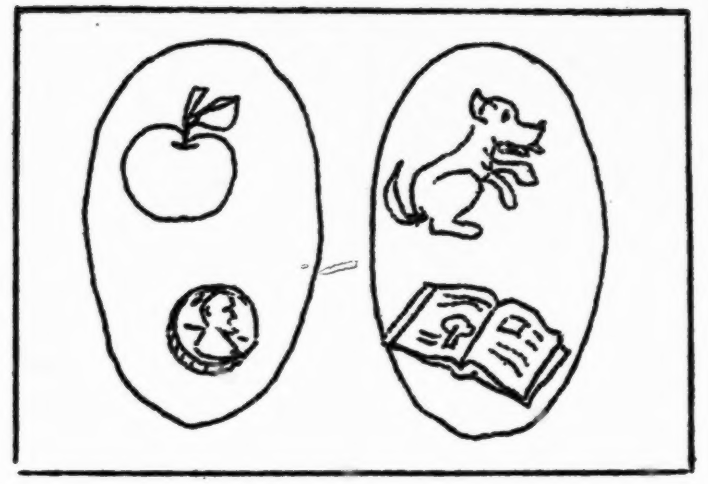


Diagram 1.

2. Materials: Diagram 2 of two empty ovals, and five clothespins. Place clothespins as shown in the Illustration 1. Say: "Make these sets match one-to-one." Any proper match, i.e., 0-0, 1-1, or 2-2 acceptable.

1 credit

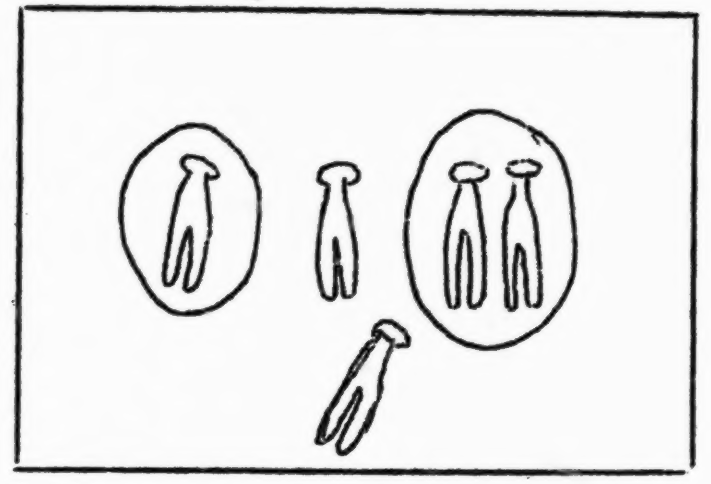


Illustration 1. (Diagram 2.)

3. Materials: Diagram 3 of three empty ovals, five clothespins, two spoons, one each of cat, hanger and thimble. Place the objects on the empty ovals of Diagram 3, as shown in Illustration 2. Say: "Make all the sets match one-to-one." Any proper match acceptable, i.e., 0-0-0, 1-1-1, 2-2-2, 3-3-3.

1 credit

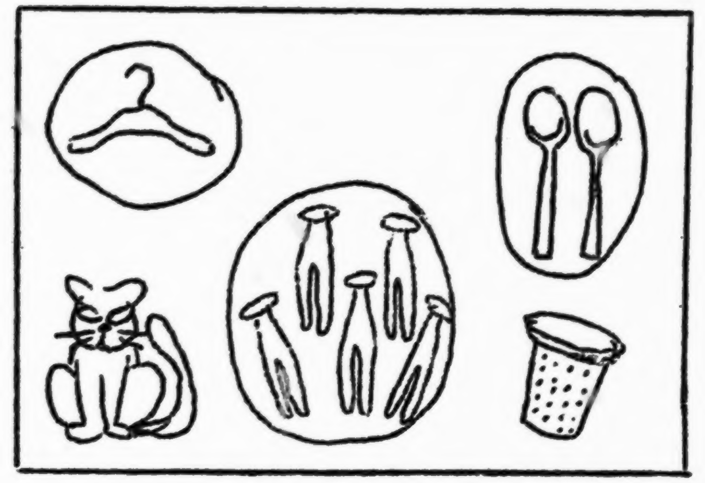


Illustration 2. (Diagram 3.)

4. Materials: Diagram 3 of three empty ovals, one each of thimble, clothespin, doll, cup, spoon, and fork. Arrange objects as shown in Illustration 3. Say: "Make all the sets match one-to-one." Any proper match is acceptable, i.e., 0-0-0, 1-1-1, 2-2-2.

1 credit

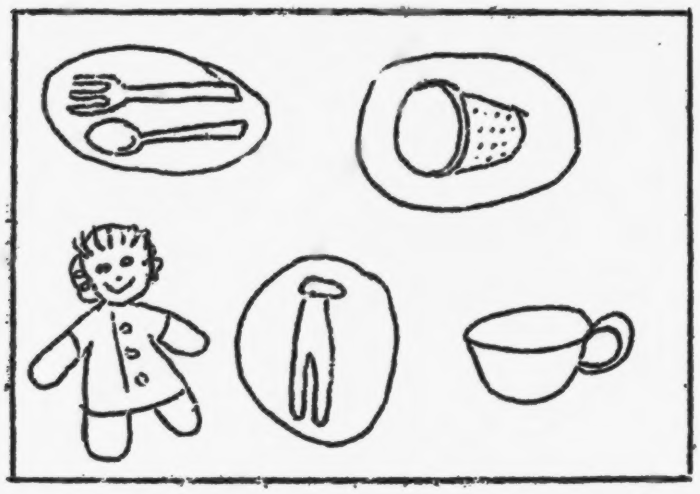


Illustration 3.(Diagram 3.)

5. a. Complete these sentences by writing the proper numerals and symbols in the placeholders.

a. $1 + 2 = \square$

b. $4 \square 5$

c. $3 \square 2$

d. $4 + 1 \square 5$

e. $1 + \square = 4$

f. $3 \square 2 = 5$

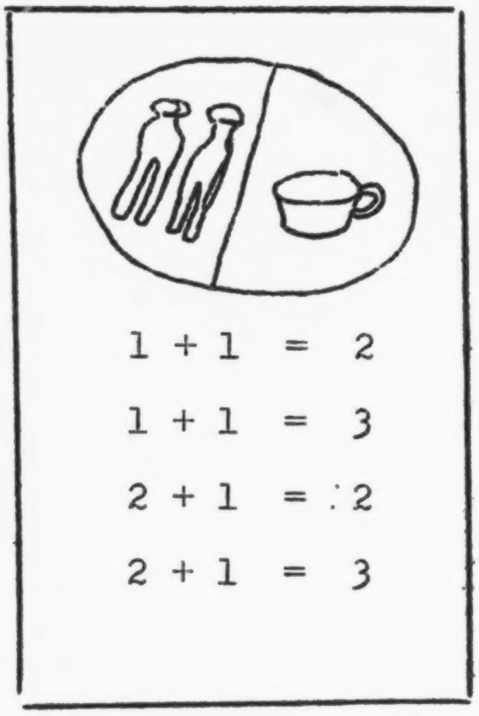
6 credits

b. Read the sentences you have completed.

6 credits

6. Materials: Diagram 4 of divided oval and number sentences, two clothespins, one cup. Place objects on divided oval as shown in Illustration 4. Say: "Point to the sentence which describes this set."

1 credit



$1 + 1 = 2$

$1 + 1 = 3$

$2 + 1 = 2$

$2 + 1 = 3$

Illustration 4.
(Diagram 4.)

7. Point to Diagram 5. Say: "Point to the sets which have the same number attribute."

1 credit

Say: "Point to the sets which have different number attributes."

1 or 2 credits

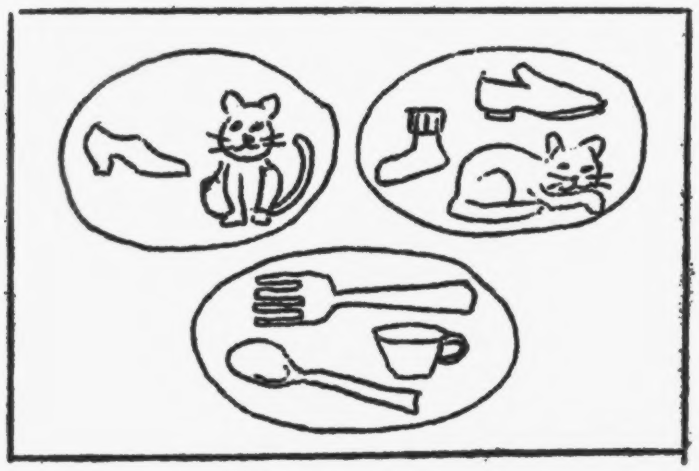


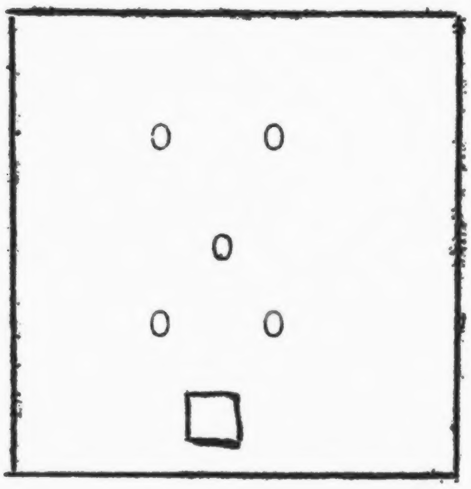
Diagram 5.

8. Compare three and two by writing the correct number sentence.

1 credit

9. Point to the picture. Say: "Look at the discs. Write in the placeholder the numeral that tells how many."

1 credit



10. Materials: Diagram 6. Say: "Point to the phrase or phrases that are equal to five.

1 or 2 credits

4 + 1	1 + 1
3 + 1	3 + 2
2 + 1	2 + 2

Diagram 6.

11. Materials: Diagram 7. Say: "Count aloud the number of objects in line."

no credit

a. "The position of the boy is . . . (first)."

b. "The position of the dog is . . . (third)."

c. "The position of the girl is . . . (second)."

d. "The position of the cat is . . . (fourth)."

e. "The position of the mouse is . . . (fifth)."

5 credits
(Credit on ordinal responses.)

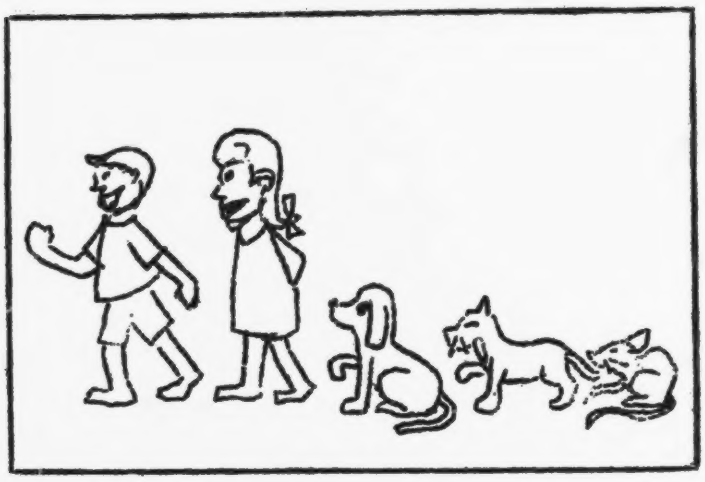


Diagram 7.

Criterion Test Materials: Seven diagrams, five clothes pins, one clothes hanger, 1 thimble, two spoons, one cat, one doll, one cup, and one fork.